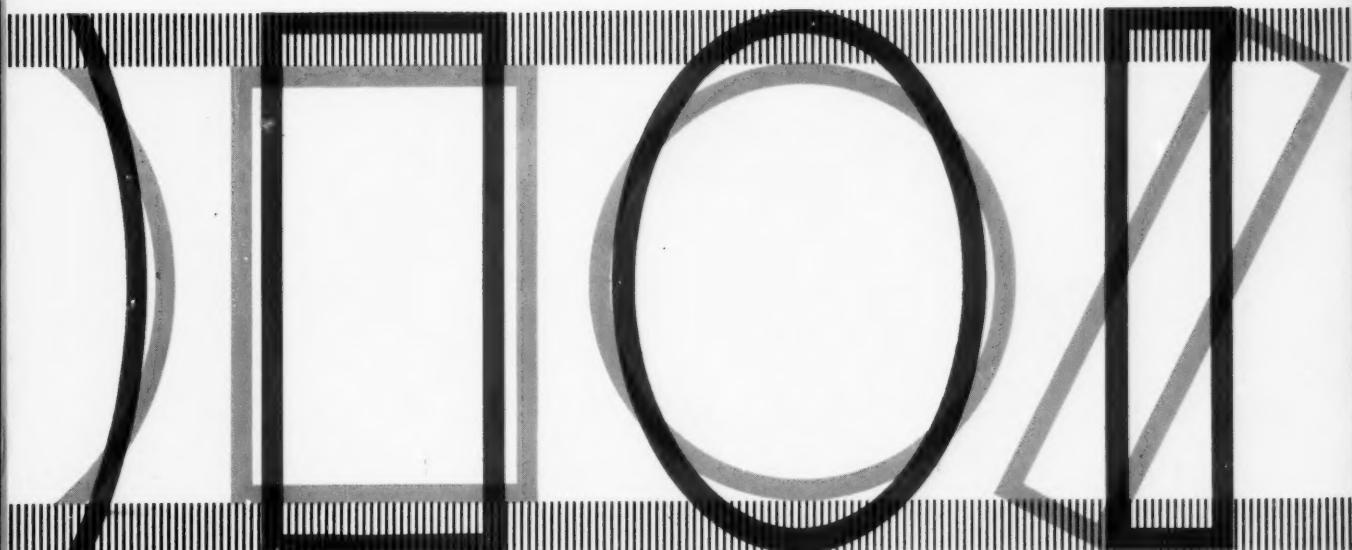


APRIL 13, 1961



DESIGN

A PENTON PUBLICATION — BIWEEKLY



Elastic-Body Mechanics

Contents, Page 3

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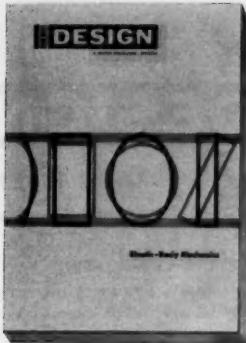
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61-8



April 13, 1961

Front Cover: The before-and-after figures depicted by George Farnsworth on this issue's cover illustrate some of the basic principles of elastodynamics. Author C. W. Musser tells us, in his article starting on Page 150, how these and other properties of materials can help to solve difficult design problems.

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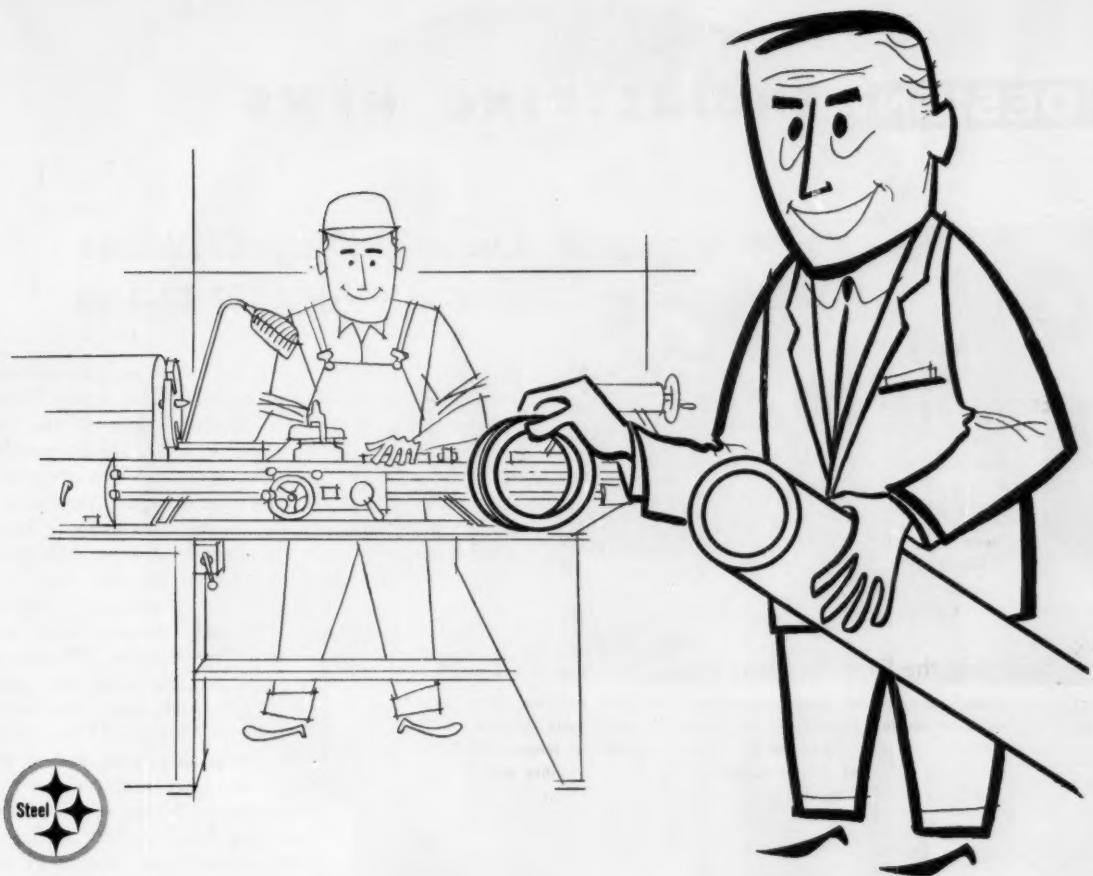


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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. Other countries: One year, \$25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by
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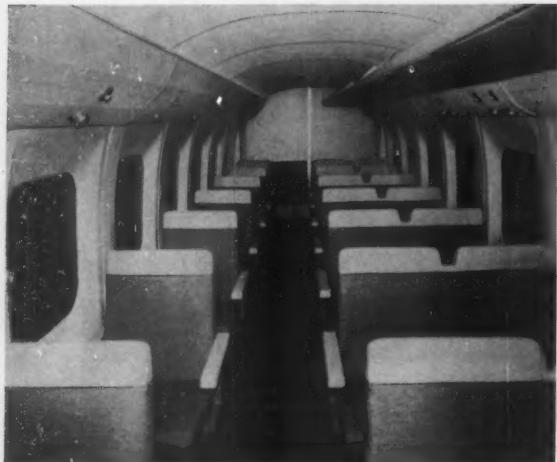
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April 13, 1961

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Comfort and Cargo Capabilities Stressed in Vertol 107 Mockups

MORTON, PA.—Hovering in high style isn't an advertised feature, but it's an obvious capability for a new "luxury" version of the Vertol 107—Boeing's twin-turbine, twin-rotor helicopter. Demonstrated in full-scale mockup form, the airliner interior (for 25 passengers) was designed for Vertol Div. by Walter Dorwin Teague Associates. A military-cargo mockup of the 107, featuring a built-in cargo-handling system (2 tons loaded or unloaded in 3 minutes) was demonstrated earlier this year.

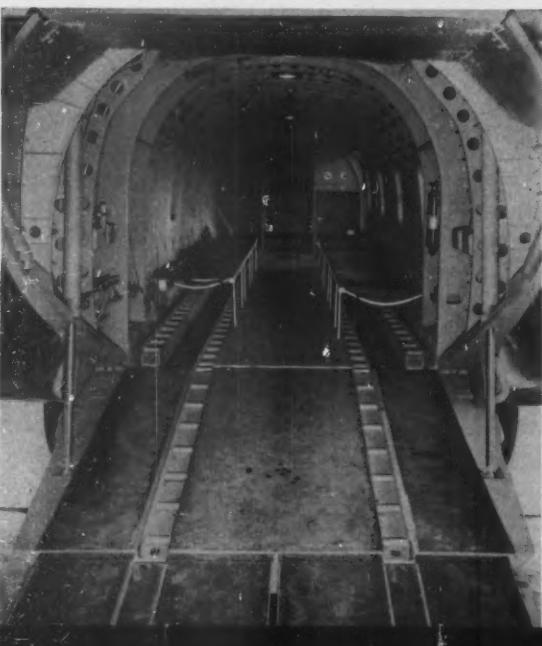
Convenience and comfort for passengers, durability and ease of maintenance for the operator, were factors dictating the design of the airliner version. Theatre-type fold-up seats make for easy passenger entry and exit. Double-pane "picture windows"—17 by 19 in.—with inner Plexiglas panes tinted gray, cut glare and make curtains unnecessary. Nylon seat upholstery and fiber floor covering are fastened with special tape, instead of metal fasteners, to simplify removal for cleaning.

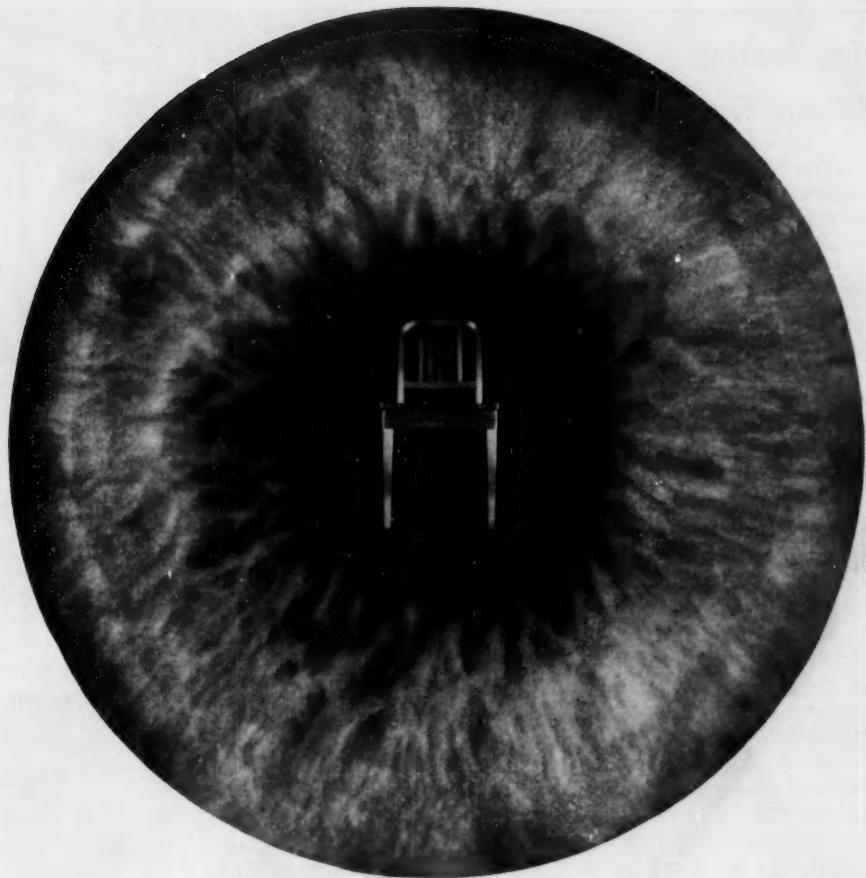
Integrated cargo system in the military 107 saves 80 per cent of conventional helicopter unload/load cycle time, says Vertol. Designed to permit one-man cargo handling, the system comprises two roller-equipped 20-ft cargo beams which serve as ramp extensions. A hydraulic winch pulls cargo pallets up the ramp onto recessed-roller tracks in the floor.

Amenities of jet-age flight—including fresh-air outlets, call buttons, and reading lights for each passenger—are part of the 107 interior (top photo). The twin-turbine Vertol is scheduled for operation with New York Airways this year.

Slight nose-up attitude permits "taxi-drop" unloading with the 107 military version. Gravity moves cargo out of the fuselage and down the ramp, while the helicopter taxies forward to distribute the load along the ground (center photo).

Recessed-roller tracks in fuselage floor and ramp (bottom photo) permit one man to carry out the load/unload cycle in 6 minutes, says Vertol. Under field conditions, conventional helicopters require about 40 minutes for the operation.





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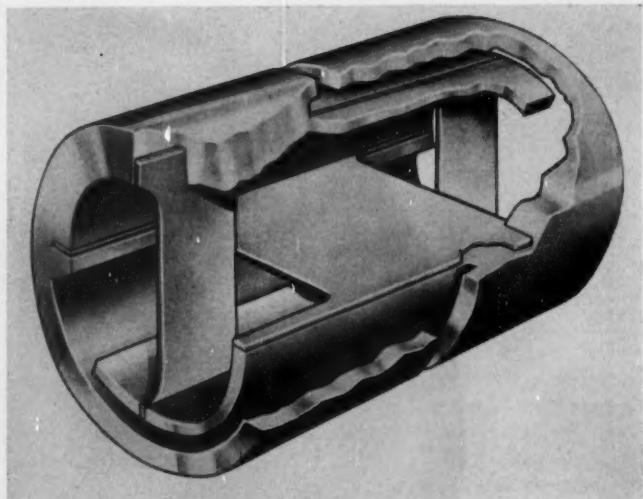
UTICA, N. Y.—The Flexural Pivot, a new type of tubular nonfriction bearing developed by Bendix Corp., may open areas of application for the devices where cost has been prohibitive. Needing only simple machining of mating parts, the precision Pivot has replaced ball-bearings in air-data sensors where close-tolerance assemblies required machining to 0.0003 in.

The new packaged nonfriction bearing is claimed to be the first cross-spring type that is not bulky, does not have a number of small parts, and meets wide manufacturing and operating standards. There is no contamination problem in manufacture, storage, or operation.

A Flexural Pivot can be used in bearing applications where angular movement required is 60 degrees or less, says Henry Trouege, its designer. It combines zero radial play with zero friction. Flexure of the flat springs, mounted at right angles to each other to separate halves of the tubular bearing, allows no rubbing of one part against the other.

Units operate without backlash or hysteresis, and no lubrication is necessary. Other features include long service life, low spring constant, high electrical conductivity, and simplicity of installation (a matter of fastening down three screws). In addition, the Pivot operates at maximum efficiency in radiation, high temperature, and vacuum environments.

Two types of the new bearing are now in full scale production: A cantilever type to support an overhung load, and a double-end type to bridge-support a central load. One end of the cantilever type can be rotated relative to the other, but the ends of the double-end types are connected and can only be rotated relative to the center section. Standard sizes are now manufactured in diameters to $\frac{3}{4}$ in.



Two concentric cylindrical sleeves, each having one end partially cut away, interconnect through flat crossed springs. Separated into sections along the longitudinal axis, the nested sleeves permit relative rotation within the 60-degree design range. In the cantilever type (above), one end rotates relative to the other. In the double-end support type (below), ends rotate relative to a center section.



Ferrous Parts Toughened by New Nitriding Process

DETROIT—Improved operating characteristics for a variety of plain and alloy steels is offered by a new (to the U. S. and Canada) nitrogen-impregnating technique. Called Tufftriding, the process applies a controlled concentration of nitrogen to raise wear resistance and toughness of any ferrous metal.

According to the exclusive U. S. licensee, Koline Corp., Detroit, Tufftriding increases corrosion resistance (except for stainless steels), raises resistance to galling, provides better wear properties, increases fatigue strength, reduces cracking, and raises rolling-fatigue limits. Contrasted



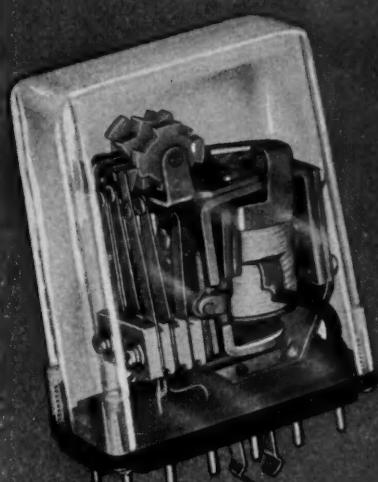
Spun between progressively loaded V-notched jaws of a lubricant-testing machine (without lubrication), untreated $\frac{1}{4}$ -in. test pin failed by seizing after 5 sec and 400 lb max load. Tufftrid pin showed no seizure, but failed instead by plastic deformation after 55 sec and 1400-lb maximum load. Test pins are 3135 steel.

with conventional nitriding, the chemical technique exposes treated parts to a relatively low-temperature (1050 F) bath. Since time at temperature is shortened, possibility of distortion is minimized.

The technique has proved out, says Koline, in experimental and production runs on practically every type of wear, shock, and cast part used in the U. S. automotive and aircraft industries. Typical parts treated are crank and cam shafts, gears, rocker arms, cylinder liners, and dies. Tufftriding is particularly effective on wear parts where lubrication is difficult or impossible.

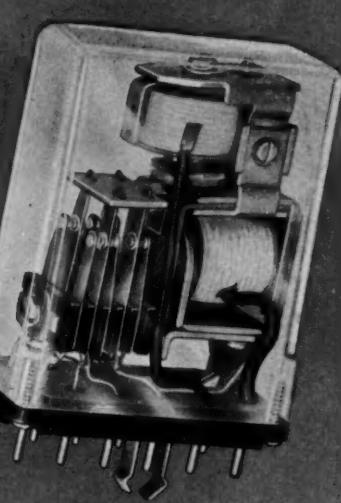
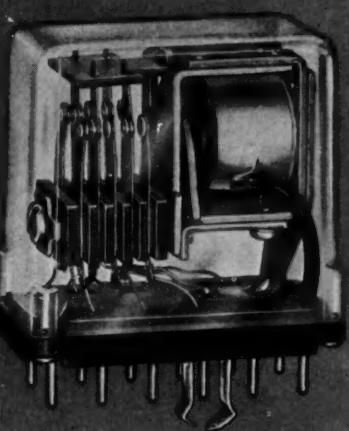
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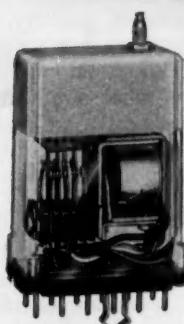


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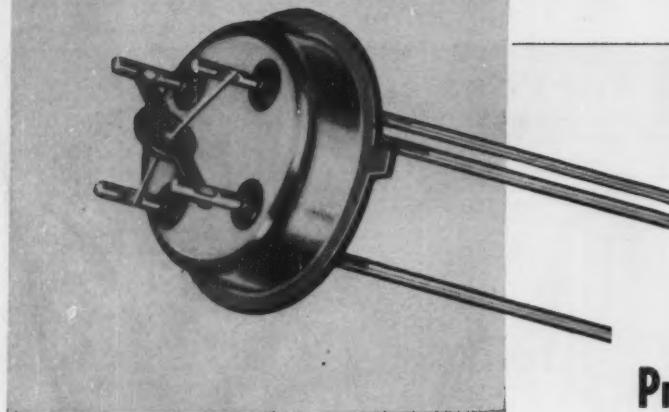
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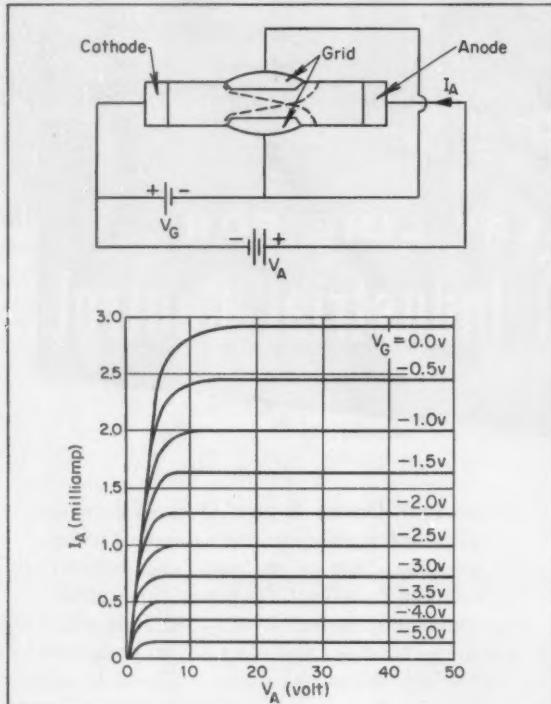
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Ten models of the field-effect transistor are in production—six as amplifiers, four as switches. All are supplied in the standard TO-5 package and can be mounted in any position. Anode and cathode terminals can be interchanged, although higher transconductance and lower noise results when the units are wired in the specified manner.



Two p-n junctions, "beaded-in" an n-type silicon bar, form the grids on the field-effect transistor. When a negative bias is applied to the two parallel grids, holes in the p-material and free electrons in the silicon migrate away from the junctions. The grids project depletion layers (shown by the dotted lines, above) into the bar, increase anode-to-cathode resistance, and give rise to a triode type of output. In the anode-grid circuit, junctions are reverse biased by anode voltage (anode is n-material), extending the depletion layer deeper into the silicon. As anode voltage increases, the two depletion layers approach each other and eventually pinch off further increases in anode current. Above pinch-off voltage, output characteristics resemble those of the thermionic pentode.

Out-of-the-way junctions
Quiet a new semiconductor

Field-Effect Transistor Promises High Reliability

A NEW kind of transistor is threatening its cousins with the same fate they forced on vacuum tubes. The device, called a field-effect transistor, was predicted by the experts more than ten years ago. Combining the strong points of tubes and transistors with several characteristics not shared with either, it gives the electronics industry the best-performing "triode" yet conceived.

Developed by Crystalonics Inc., Cambridge, Mass., the field-effect transistor differs from other types in that electron paths from cathode to anode don't pass through p-n junctions. Because these junctions, or surfaces, are the major contributors to transistor instability, reliability of the device is about the same as that of the silicon diode—four times greater than conventional transistors. And because surface conditions have no effect on FET operating characteristics, production headaches involving cleanliness, passivity, inertness, and stability are virtually eliminated.

Exhibiting extremely high impedances and low noise levels, field-effect transistors, like tubes, are voltage operated, and their electrical characteristics are similar to the thermionic pentode. But like other transistors, they are not subject to microphonic effects and have no heating elements.

The new components do more than replace other devices; they open new applications. When used as a switch, for example, the FET is a "normally on" device. Completely passive and possessing no offset voltage, it switches signals on the order of one microvolt. Switching ability is limited only by inherent noise levels. Switching speed can be as low as 10 nanosec. Speed is limited by external components and internal capacitances of the device, but even in applications where voltage gain is desired, switching speeds can approach 50 nanosec.

Negative voltage is required on the control electrode to switch off the FET, and there is no mixing between signal and drive currents (except for transient phenomena). In steady state, grid and anode-cathode circuits of the switch are isolated from each other by reverse-biased p-n junctions.



creative nuclear fission...

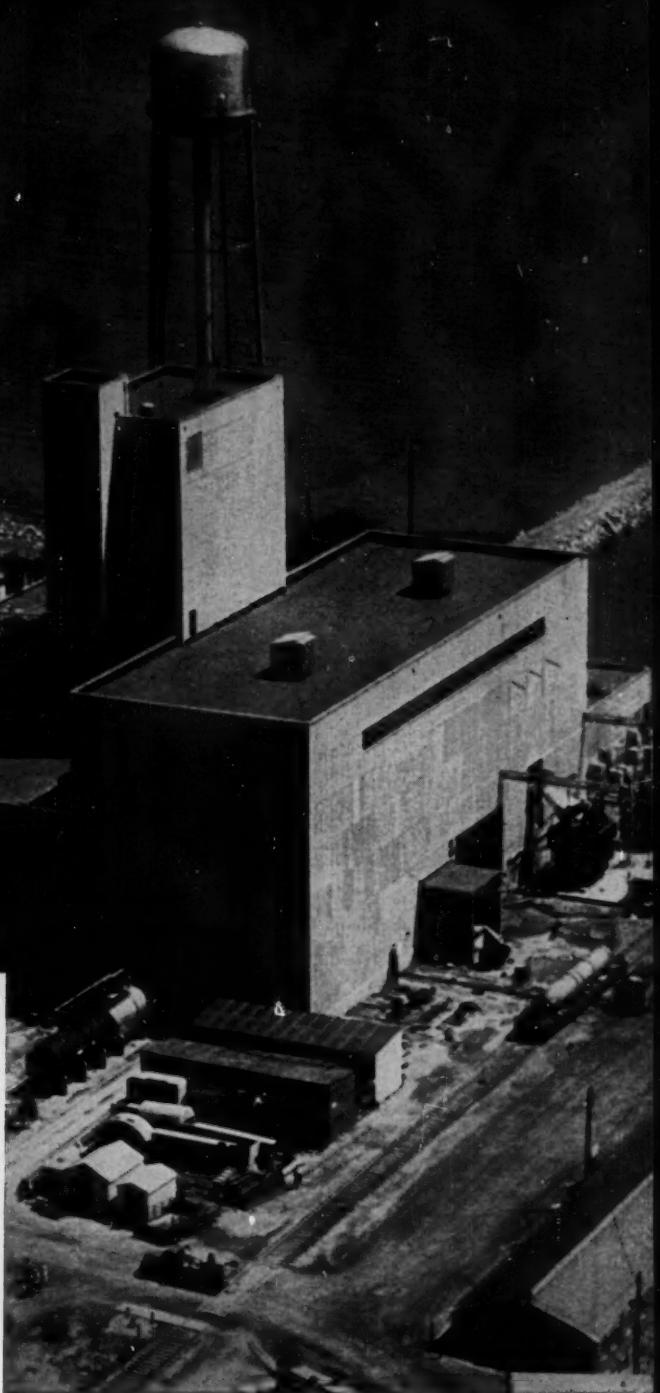
The breeder reactor of the Enrico Fermi Atomic Power Plant at Lagoona Beach, Michigan, is designed to produce 20 per cent more fuel than it consumes—creative nuclear fission!

Carlson Type 304 stainless steel plate was fabricated into the reactor vessel by Combustion Engineering, Inc. This plate must withstand the high temperatures and severely corrosive conditions associated with nuclear service.

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Circle 209 on Page 19



Weight comparison shown here for beryllium and steel actuators, while striking, doesn't represent full potential for the lightweight metal since all hardware used to assemble the beryllium unit was steel. Designed to power a radar antenna, the actuator relies on close clearances (0.0001 to 0.0004 in.) rather than seals to hold down leakage between moving parts. Converting the design from steel to beryllium required only the addition of press-fitted nitrided-steel sleeves for bearing inner and outer races.

Beryllium Shows Potential for Lightweight Hydraulics

BALTIMORE, Md.—Built almost entirely of beryllium (only the fasteners are steel), the airborne rotary actuator shown above may be the prototype for a new breed of lightweight fluid-power components. Nearly 75 per cent lighter than an all-steel predecessor, the experimental unit has proved its potential in two-year tests by Westinghouse Electric's Air Arm Div.

Lower weight and greater structural stiffness (to reduce end-plate deflection) were first-order design objectives behind the conversion from steel to beryllium, reports developer James H. Renshaw. Comparable in weight to magnesium, beryllium is lighter than steel by almost a 4:1 ratio. On a strength-to-weight basis, it exceeds steel by 3:1. Stiffness (modulus of elasticity) is about 50 per cent higher.

Acknowledging these desirable properties, developers of the unit organized their test program to uncover a wide range of characteristics pertinent to the operation of beryllium hydraulic units:

- **Compatibility with seals and fluids.** A beryllium sample, placed in MIL-H-5605 hydraulic fluid at 250 F, was unaffected after an extended soak. Accelerated life tests (over 500,000 cycles) turned up no evidence of unusual abrasive action

of the beryllium on O-rings.

- **Temperature extremes.** Temperatures covering the range from -65 to 230 F were applied to both steel and beryllium actuators. Data (taken at 500 and 100 psi fluid pressures) showed equal effects of temperature on breakaway friction and internal leakage.

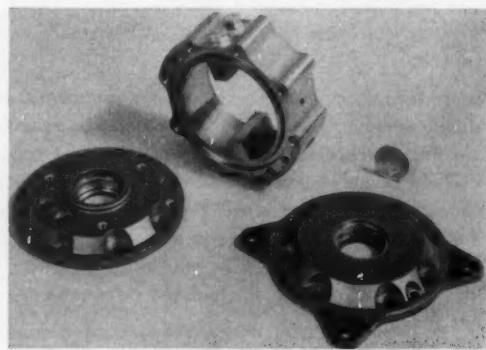
- **Friction and wear.** Electrolyzed surfaces at critical wear points gave "encouraging" results. The hard-surfacing process—applied for the first time on functional beryllium parts, says Westinghouse—shows promise as a means of holding friction and wear to acceptable levels. Quality of machined surfaces on beryllium actuator parts was satisfactory, although close observation showed that surfaces were covered

with microscopic indentations or pits. This may be a characteristic that can be attributed to the hot-sintered raw material, says Renshaw. Developers are considering use of extruded rod stock, which reportedly has excellent properties in the direction of extrusion, plus higher hardness throughout.

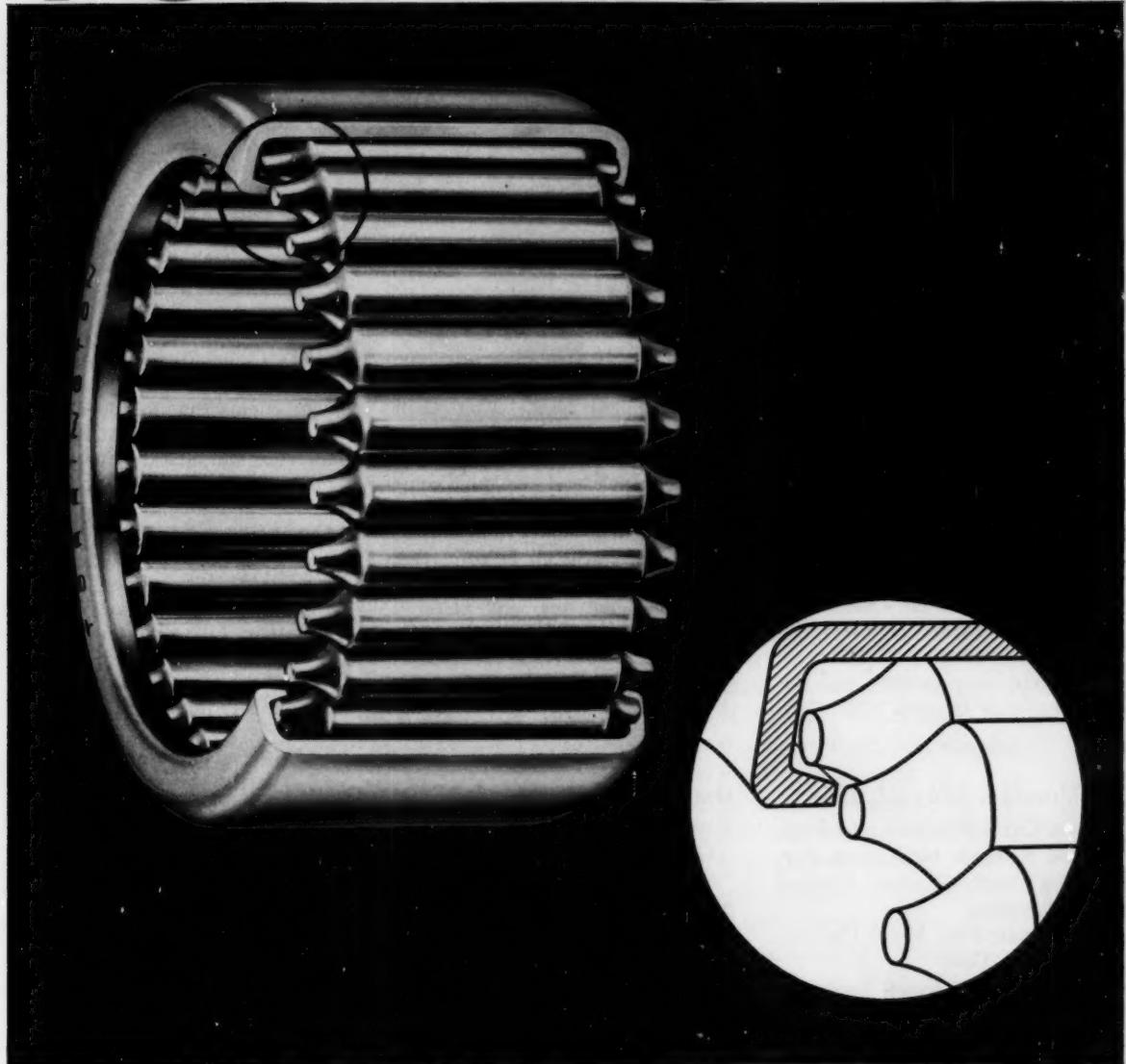
Sharp corners, which were important in the actuator design, were acceptable. Brittleness of the beryllium was evident, however, since a microscope revealed that parts were chipped along their entire length.

Developers of the lightweight actuator, while concluding that beryllium has a promising future in the hydraulic field, point out that there is still room for improvement in properties such as notch sensitivity, brittleness, and strength.

Careful handling of beryllium parts such as these was found to be necessary during all stages of manufacture. Contact with other materials used in jigs and test fixtures often resulted in serious surface scarring. Units shown were fabricated for Westinghouse by Pioneer Astro Metallics Corp., Chicago.



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bearing of comparable size. Precision rollers insure smooth, highly efficient performance, with a minimum of starting and running friction.

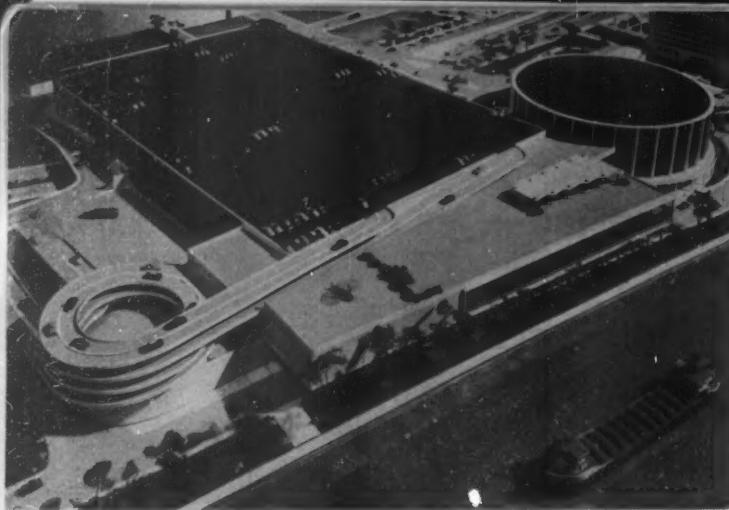
This bearing is compact, lightweight, economical. Its unit cost is surprisingly little. For details on how the Torrington Drawn Cup Needle Bearing can help your product, call or write Torrington...pioneer in needle bearings and maker of every basic type of antifriction bearing.

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Design Engineering Show Set for May 22 Opening

*Detroit's Cobo Hall
Houses Five-Acre Exhibit,
Four-Day Conference*

DETROIT—New products and parts—\$10 million worth—will be unveiled here next month when the Design Engineering Show and Conference takes over Cobo Hall. Over 400 companies will exhibit their new wares, and over 4000 experts will be on hand to answer questions.

One of the largest expositions ever held in the U.S., the show will run four days—from May 22 through May 25—and will be attended by an estimated 20,000 engineers and engineering managers.

Research, development, and design engineers charged with plan-

ning products will have an opportunity to study virtually every type of component and engineering service they might need. More than 100 companies will show new types of materials. Mechanical components, electrical and electronic components, power-transmission equipment, fasteners, adhesives, finishes, coatings, etc., will all be displayed, a total of 15,000 products.

At the same time and place, a four-day conference will be conducted by the Machine Design Division of American Society of Mechanical Engineers. Theme for the

conference will be "Designing for Today's Competitive Market." The first day will be entirely devoted to design engineering in the automotive field; on following days the conference will consider specific design problems and will split into separate simultaneous sessions.

Conference sessions will begin each day (except Monday) at 9:30 a.m. The Monday session will begin at 10:00, allowing extra time for registration. All sessions will finish in the forenoon, permitting members to attend the show in the afternoon. Schedule is as follows:

Monday, May 22, 1961

How a Car Is Planned and Engineered to Meet Marketing, Purchasing and Quality Control Considerations

Will Scott, Ford Motor Car Co., Dearborn, Mich.

Engineering Approach for Maximum Sales Value per Unit of Cost

H. M. Bevans, Chrysler Corp., Detroit

Production Engineering of the Design of a New Car

Conrad Orloff, Chevrolet Motors Div., General Motors Corp., Detroit

Role of the Supplier

Carl E. Burke, American Motors Co., Detroit

Tuesday, May 23, 1961

(Concurrent Sessions)

1—Design for Production

C. E. Warner, General Electric Co., Schenectady, N. Y.

R. L. Berg, Consultant, General Electric Co., Schenectady, N. Y.

Materials Standardization to Reduce Costs

Gerald Swastwood, Bryant Electric Co., Bridgeport, Conn.

2—Special Requirements of Hydraulic Circuits for Servo-Controlled Machinery

Robert K. Sedgwick, Kearney & Trecker Corp., Milwaukee

Drives for Tape-Controlled Machine Tools

George W. Younkin, Giddings & Lewis, Fond du Lac, Wis.

3—Ceramic Materials: A Chemical and Structural Description

Dr. Marvin Britton, Corning Glass Works, Corning, N. Y.

What Do Glasses and Ceramics Offer the Design Engineer

J. R. Blizard, Corning Glass Works, Corning, N. Y.

4—High-Strength Steels, Their Characteristics and Workability

Dr. Ray Lula, Allegheny Ludlum Steel Co., Pittsburgh

Design of Structural Members Made by Forming High-Strength Steel Sheet

Richard Marvin, The Budd Co., Philadelphia

Wednesday, May 24, 1961

(Concurrent Sessions)

5—Electric Motors at High Temperatures for Industrial Usage

Frank Rushing, Westinghouse Electric Corp., Buffalo, N. Y.

Application of Non-Excited Synchronous Motors

J. P. Landis, E. I. duPont deNemours & Co., Wilmington, Del.

6—Design and Drafting Techniques for Parts Manufacturing on Numerically Controlled Production Equipment

Alexander Taleff, Westinghouse Electric Co., Pittsburgh

Cost versus Value of Small Tolerances and Smooth Finish

Dr. W. W. Gilbert, General Electric Co., Schenectady, N. Y.

7—Adhesives, Types and Characteristics

W. C. O'Leary, Minnesota Mining and Manufacturing Co., St. Paul, Minn.

Design with Adhesives

Dr. A. F. Charter, A. O. Smith Co., Milwaukee

8—New Developments in Types of Fasteners

John Stoutenburg, Robin Products Co., Warren, Mich.

Designing with Powder Metallurgy to Improve Quality and Reduce Cost

Paul J. Failla, Johnson Bronze Co., New Castle, Pa.

Thursday, May 25, 1961
(Concurrent Sessions)

9—Filament-Wound Pressure Vessels

Richard Gorcey, Rocketdyne Div., North American Aviation Inc., Canoga Park, Calif.

Design of Plastic Parts for Strength and Durability

R. L. Thorkildsen, General Electric Co., Schenectady, N. Y.

Dr. J. V. Schmitz, General Electric Co., Louisville, Ky.

10—Visco-Elastic Damping

D. K. Hatch, Monsanto Chemical Co., Springfield, Mass.

Method of Analysis for Gears

Merriwether Baxter, Gleason Works, Rochester, N. Y.

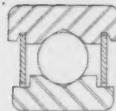
11—Moly-Disulphide Lubricants

K. B. Wood, Climax Molybdenum Corp., New York

Moly-Disulphide as a Grease Additive

H. G. Rudolph Jr., Soconoy Mobil Oil Co., New York

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Cutaway showing
built-in shields

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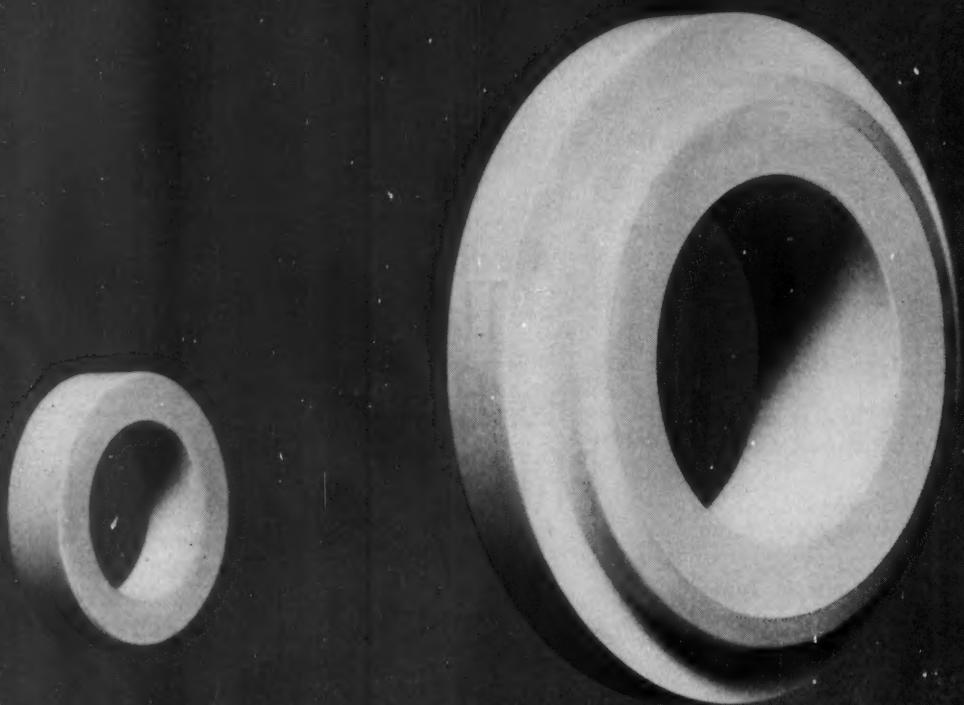
Complete technical data on this extra-thin bearing is available in our Tech-Tonic #8, or for information on how ITI can design and produce in quantity other special bearings having corrosion resistance, unusual configuration, or high temperature capabilities, write for Bulletin AFB-2.



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Circle 212 on Page 19



Reader Information Service

Circle number on
Yellow Card for

- Free catalogs, bulletins, literature
- Information about new parts, materials
- Design data on advertised products
- Extra copies of editorial articles

HELPFUL LITERATURE

Electrical, Electronic

603 Silicon Rectifiers. 6 pp. Semiconductor Div., Syntex Co.
 605 Adjustable-Speed Drives. 8 pp. Westinghouse Electric Corp.
 607 High-Speed Computing System. 18 pp. Bendix Computer Div., Bendix Corp.
 609 Temperature Controls. 8 pp. Fenwal Inc.
 610 Connector Protectors. 4 pp. Plastic Div., S. S. White Industrial Div.
 615 Transistor Transformers. 4 pp. Deco Inc.
 625 Miniature Panel Meters. 4 pp. International Instruments Inc.
 632 Liquid-Level Controls. 4 pp. B/W Controller Corp.
 645 Silicon Mesa Transistors. Two bulletins, 6 pp. each. Semiconductor Products Dept., General Electric Co.
 646 Size-8 Components. 12 pp. Kearfott Div., General Precision Inc.
 717 Adjustable-Speed Drives.* For 3/4 to 2500-hp ranges. Bulletin 2900, 6 pp. Louis Allis Co.
 718 Magnetic Shields.* Selection data on shields and shielding materials. 16 pp. James Millen Mfg. Co. Inc.
 719 Mercury Lamps.* Electrical and physical characteristics, applications. Booklet A-7264, 28 pp. Lamp Div., Westinghouse Electric Corp.
 720 Timing Modules.* Covers time delays from 0.1 to 60 sec. Bulletin PD-1016, 5 pp. G-V Controls Inc.
 721 Printed-Circuit Connectors.* Right-angle pin and socket types. Form RTA-1260, 12 pp. DeJure-Amsco Corp.
 722 Aluminum Integral Motor.* Specifications, construction features, availability. Bulletin P-86035-AU, 8 pp. Franklin Electric Co. Inc.
 723 Limit Switches.* For automatic pilot control. Bulletin GEA-7312, 12 pp. General Electric Co.
 724 Motor Starters.* For fractional-horsepower motors. Bulletin 10-B1, 8 pp. Furnas Electric Co.
 725 Vertical Motors.* Integral-horsepower units. Bulletin 1485, 2 pp. Century Electric Co.
 726 Door Interlock Switches.* Safety devices on hazardous electronic equipment. Data Sheet 186, 4 pp. Micro Switch Div., Minneapolis-Honeywell Regulator Co.
 727 Silicone-Insulated Cable.* For shipboard, missiles, nuclear devices. 4 pp. Boston Insulated Wire & Cable Co.

Hydraulic, Pneumatic

608 Aircraft Hydraulic Filters. 8 pp. Poll Corp.
 612 Centrifugal Pumps. 16 pp. Goulds Pumps Inc.
 616 Metallic Static Face Seals. 4 pp. Haskel Seal Div., Haskel Engineering & Supply Co.
 622 Metallic Seal. 8 pp. Del Mfg. Div., Arrowhead & Puritas Waters Inc.
 626 Centrifugal Pumps. 4 pp. National Carbon Co., Div., Union Carbide Corp.
 638 Turbine Flowmeters. Two bulletins, 14 pp. total. Fischer & Porter Co.

Descriptions of items start on Page 203. Starred items are from March 30 issue.

Mechanical Equipment

601 Stamped Gears. 16 pp. Winzeler Mfg. & Tool Co.
 618 Self-Aligning Bearings. 56 pp. Southwest Products Co.
 621 Adjustable-Speed Belts. 8 pp. Manheim Mfg. & Belting Co.
 623 Adjustable-Speed Belts. 14 pp. Lovejoy Flexible Coupling Co.
 627 Chain Drives. 125 pp. Foote Bros. Gear & Machine Corp.
 634 Miniature Bearings. 16 pp. Landis & Gyr Inc.
 637 Power-Transmission Equipment. Browning Mfg. Co.
 733 Rod Ends, Bearings.* Data on Alinabol units. Catalog 101, 12 pp. Split Ballbearing Div., MPB Inc.
 734 Power-Transmission Equipment.* Adjustable-speed pulleys, belts, sheaves, etc. Catalog 61-B, 34 pp. Lovejoy Flexible Coupling Co.
 735 Speed Reducers.* Single, compound, double-planetary types. Catalog P-61, 18 pp. Philadelphia Gear Corp.
 736 V-Belt Clutches.* Standard and custom Ball-Lok units. Catalog 40, 16 pp. V-Belt Clutch Co.
 737 Oilless Bearings.* Metal-plastic units for high speed, load capacities. Catalog 511, 12 pp. Arguto Oilless Bearing Co.

Assembly Components

602 Spring-Tension Fasteners. 4 pp. Associated Spring Corp.
 611 Retaining Rings. Two catalogs, 4 pp. each. Industrial Retaining Ring Co.
 613 One-Piece Metal Enclosures. 2 pp. Barber-Colman Co.
 614 Push-Type Insert. 2 pp. Heli-Coil Corp.
 615 Corrosion Guide. 24 pp. H. M. Harper Co.
 628 Torque-Tension Manual. 18 pp. Elastic Stop Nut Corp. of America.
 631 Industrial Fasteners. 8 pp. Standard Pressed Steel Co.

635 Timing Screws. 4 pp. Arthur Colton Co.
 641 Self-Locking Cap Screw. 4 pp. Klincher Kap-screw Inc.
 738 Self-Locking Fasteners.* Lightweight units for avionic, electronic use. Catalog 960, 64 pp. Elastic Stop Nut Corp. of America.
 739 Self-Locking Blind Nut.* Operation of Davis press nut & pp. Standard Pressed Steel Co.
 740 Stainless-Steel Clamps.* For flexible plastic pipe. Sheet PP-1160, 2 pp. Wittek Mfg. Co.

Manufacturing Processes, Parts

633 Welded Steel Designing. 4 pp. Lincoln Electric Co.

Materials

604 Advanced Materials. 8 pp. Corborundum Co.
 619 Thermoplastics Properties. 4 pp. A. L. Hyde Co.
 624 Potting Compound. 4 pp. Silicone Products Dept., General Electric Co.
 636 Nylon Stock Shapes. 4 pp. Polymer Corp.
 644 Rulon, Teflon Parts. 4 pp. Plastics Div., Dixon Corp.
 647 Expanded-Foam Plastic. Pac-Tron Inc.
 741 Structural Tubing.* Square, rectangular, round steel for structural uses. Bulletin 12-3, 4 pp. Joseph T. Ryerson & Son Inc.
 742 Dialyl-Phthalate Varnishes.* Formulations and uses. Bulletin 32, 8 pp. Dapon Dept., Food Machinery & Chemical Corp.
 743 Graphite Products.* Four-times yearly booklet on development, design, application. 6 pp. United States Graphite Co., Div., Wickes Corp.
 744 Hard Cemented Carbide.* Properties and examples of applications. 16 pp. Kennametal Inc.
 745 Precision Wire.* Moleculoy properties, characteristics, uses. 8 pp. Moleculoy Wire Corp.

Drafting and Reproduction

620 Drafting Film. Arkwright Finishing Div., Arkwright-Interlaken Inc.
 630 Drafting Aids. 6 pp. By-Buk Co.

Laboratory and Testing

606 Laboratory Oscilloscopes. 20 pp. Tektronix Inc.
 629 Bolt-Strain Gage. 4 pp. S. S. Insert Co.
 639 Torque Measurements. 12 pp. Power Instruments Inc.
 746 Rate and Acceleration Nomograph.* Useful for gyroscopes and angular accelerometers. Micro Gee Products Inc.

NEW PARTS, MATERIALS, ENGINEERING EQUIPMENT

Descriptions start on Page 218.

Electrical, Electronic

649 Photoconductive cell measures tungsten or daylight light. Clairex Corp.

651 Magnetic reed switch has 1½ in. over-all length. Hamlin Inc.

657 Alkaline batteries have long storage life. Electron Tube Div., Radio Corp. of America.

662 Fractional-horsepower motor with ratings from 1/20 to 1/4 hp. Redmond Company Inc.

664 Silicon transistors are double-ended, subminiature. Semiconductor Div., Raytheon Co.

669 Microminiature relay has height of 0.44 in. Control Dynamics Corp.

672 Synchronous motor with 1800-rpm speed. Instrument Div., Thomas A. Edison Industries.

673 Indicator tubes have 160-deg viewing angle. Electronic Tube Div., Burroughs Corp.

677 Miniature terminal boards available in any shape. Accurate Electronics Corp.

678 Switch light permits rebubbling without special tools. Master Specialties Co.

680 Subminiature potentiometer for temperatures from -55 to +200°C. Potentiometer Div., Daystrom, Inc.

684 Metallized ceramic parts are suitable for hermetic seals. Mitrionics Inc.

685 Plug and jock assembly for printed-circuit boards. Cambridge Thermionic Corp.

687 Zippered tubing has aluminum foil shielding. Zippertubing Co.

691 Miniature lamps in 14 styles. Welch Allyn Inc.

694 Ceramic capacitors are subminiature, rectangular-shaped. Erie Resistor Corp.

695 Slip-ring assembly accommodates from 15 to 30 rings. Superior Carbon Products Inc.

696 Pressure switches indicate over 15 to 2000-psi range. Pall Corp.

697 Wound-rotor motors in small-frame sizes. Reliance Electric Co.

700 Proximity switch sensitive to ferrous, nonferrous metals. Electronic Signals Inc.

705 Gear motor for use in nuclear radiation environment. Electro Products Div., Western Gear Corp.

706 Switching transistor has high switching speeds. Semiconductor & Special Purpose Tube Div., Amperex Electronic Corp.

Hydraulic, Pneumatic

650 Teflon pressure seals have stainless-steel spring insert. Raco Engineering Co.

658 Miniature directional valves for oil-hydraulic systems. Vickers Inc., Div., Sperry Rand Corp.

660 Rotary face seal for maximum pressure of 10,000 psi. Hydrodyne Corp.

666 Low-capacity pumps handle almost any type of material. Moyno Pump Div., Robbins & Myers Inc.

670 Ball valve for air and fluids compatible with bronze. Ball Valves Inc.

682 Air cylinders have adjustable strokes. Modernair Corp.

688 Vaneaxial blower delivers 68 cfm of air. Globe Industries Inc.

689 Germanium power transistors have low profile. Semiconductor-Components Div., Texas Instruments Inc.

692 Ball valves in 1/4 to 2-in. diam sizes. Hydromatics Inc.

701 Neoprene tubing has Teflon lining. Pennsylvania Fluorocarbon Co. Inc.

702 Air-operated valves for pressures to 5000 psi. Autoclave Engineers Inc.

703 Corrosion-resistant filter removes contaminants to 5 microns. Pacific Sintered Metals Co.

Mechanical Equipment

648 Shaft collar withstands high thrust loads. Bearing Accessories Co.

652 Packaged journal bearing for rotating-shaft uses. Tann Bearing Co., Div., Tann Corp.

654 Enclosed differential in BuOrd sizes 5, 8, 11, 15, and 18. Component Div., Sterling Precision Corp.

655 Compact engines for small, gasoline-powered tools. Ohlson & Rice.

656 Miniature cam followers have 1/4 to 5/8 in. ODs. PIC Design Corp.

659 Gear box transmits up to 45 hp. Von Ruden Mfg. Co.

663 Vertical speed reducers nine sizes have 4.17:1 to 95:1 ratios. Cleveland Worm & Gear Div., Eaton Mfg. Co.

676 Adjustable-speed transmission for instrument and control uses. Graham Transmissions Inc.

681 Adjustable-speed drive requires no lubrication. Sterling Electric Motors Inc.

686 Nylon-to-nylon belting for conveyor applications. Veltex & Pulver Inc.

698 Universal joints have neoprene covers. Loveloy Flexible Coupling Co.

Assembly Components

661 Plastic cable clamp supports loads to 75 lb. Hartwell Corp.

668 Nylon clamp in 1/8 to 1 1/4-in. diam sizes. Olympic Plastics Co. Inc.

671 Threaded insert makes electrical connection in molded plastic. Phelps Mfg. Div., Heli-Coil Corp.

673 Printed-circuit fastener has 8 to 1 lever ratio. Southco Div., South Chester Corp.

679 Cushion clamps resist temperatures to 1500 F. TA Mfg. Corp.

690 Cable clamps and ties are unaffected by moisture. Panduit Corp.

699 Tubular inserts for use in steel tubing. Ohio Nut & Bolt Co.

704 Perforated nylon strapping available in new sizes. Weckesser Co. Inc.

Materials

653 Two-part epoxy adhesive provides over 2000 psi shear strengths. Mereco Products Div., Metachem Resins Corp.

663 Ceramic adhesive bonds at up to 2600 F. Special Products Div., Melpar Inc.

667 Aluminum-silicon-copper alloy is pre-machining, nonmagnetic. Ampco Metal Inc.

674 Stainless steel is free-machining, has high corrosion resistance. Universal-Cyclops Steel Corp.

683 Molding-grade polypropylene for use at high temperatures. Enjoy Chemical Co.

693 Aluminum-foil marker on quick-release dispenser. North Shore Nameplate Div., Anodyne Inc.

716 Self-sticking tapes in 20 transparent colors. ACS Tapes Inc.

Drafting and Reproduction

707 Drafting table can be rotated 360 deg around base. Isis Inc.

709 Drafting film is blue-colored. B. K. Elliott Co.

710 Modular file for all types of rolled material. Hamilton Mfg. Co.

713 Drawing-board cover of resilient vinyl plastic. Unitech Corp.

714 Dry copying machine is electronically controlled. Photorapid Corp.

Laboratory and Testing

708 Miniature torque pickup for use with belt or gear drive. Lebow Associates Inc.

711 Power supply has output of 0.5 w per cu in. Valor Instruments Inc.

712 Triaxial accelerometer for shock and vibration testing. Columbia Research Laboratories.

715 Environmental chamber has 0.5 cu ft capacity. Cincinnati Sub Zero Products.

Circle the item number for information on products advertised or described, literature offered, and copies of editorial articles.

EDITORIAL ARTICLES

Single copies of the following articles are available as long as the supply lasts. Starred items are from previous issues. See Page 291 for other available reprints. Editorial content of *MACHINE DESIGN* is indexed in the Applied Science & Technology Index and the Engineering Index, both available in libraries. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

8-1 Managerial Planning. Plan-making methods for engineering managers.

8-2 Pressure Regulators. Basic principles and types; selection and application.

8-3 Elastic-Body Mechanics. New principles in using elastic properties of materials to solve design problems.

8-4 Precision Snap-Action Switches—Part 2. Mechanical and electrical requirements; operating factors.

8-5 Positioning Gear Shafts. Axial shaft-location methods for minimizing system backlash and gear-tooth wear.

8-6 Fatigue in Metal Joints—Part 2. Determining design strength of welded joints.

8-7 Designing Cam Profiles. Calculation of polynomial cam curves to fit mixed conditions of displacement, velocity, and acceleration.

8-8 Explosive Forming (Abstract). Progress report on high-energy processes for difficult forming operations.

7-1 From Engineer to Manager.* Six major routes to management.

7-5 Helical Spring Design.* A direct design procedure that eliminates trial and error.

7-6 Internal-Combustion Engines.* Factors in selecting engines up to 60 hp in size.

7-7 Tees in Bending.* Design curves for finding properties of tees and channels.

6-1 Engineering or Research.* Effect of company size on emphasis placed on engineering or research.

6-2 Conical-Disc Springs.* Designing for specific characteristics in minimum space.

6-3 Self-Sealing Couplings.* How to select air and hydraulic types for instant connection and disconnection without fluid loss.

6-8 Variable-Section Beams.* Calculating slopes and deflections when material is uniform but bending moment and moment of inertia vary.

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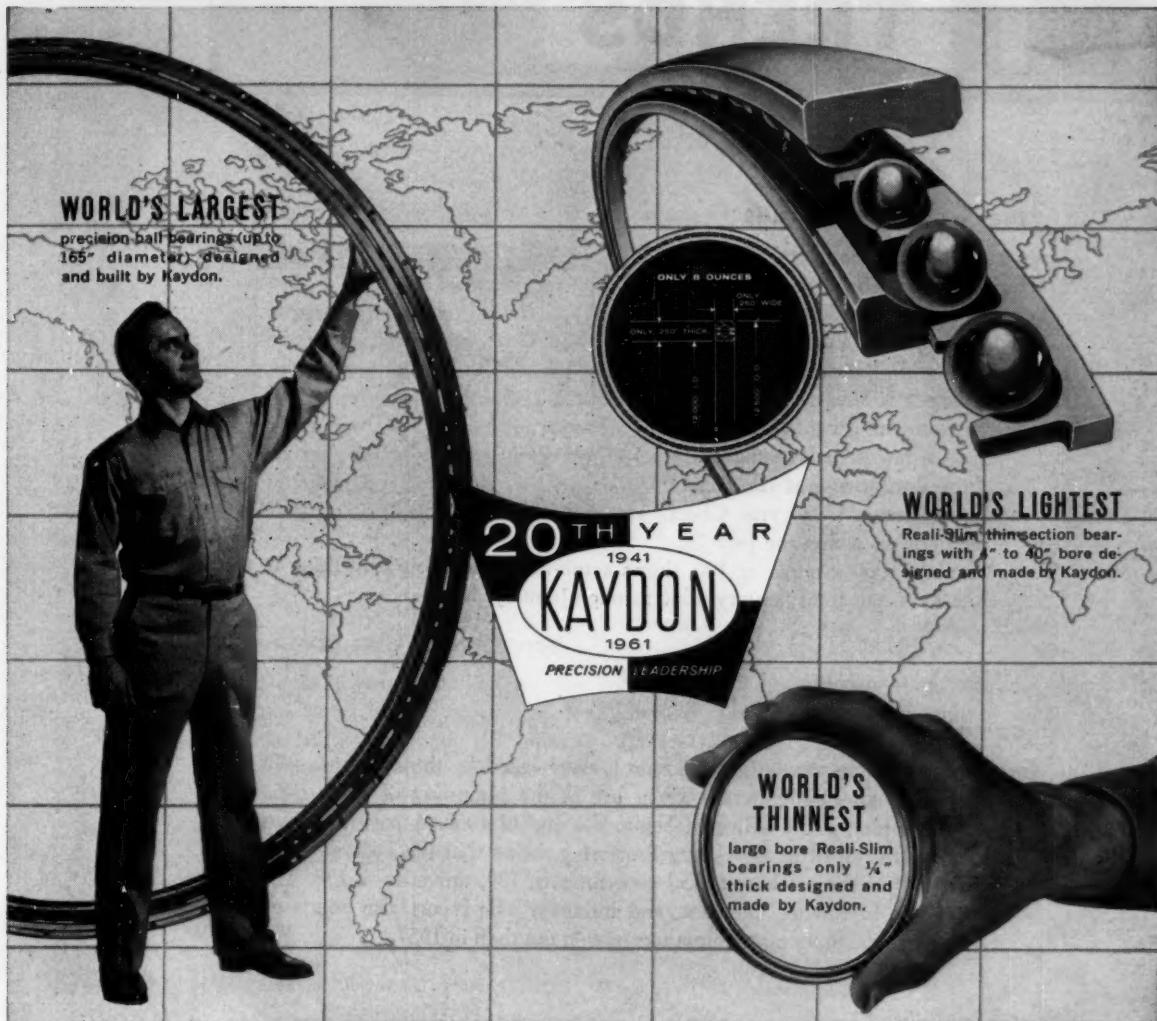
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When stock bearings "won't do"... **KAYDON** special bearings "will". Standard bearings often aren't adequate when you run up against a combination of limitations involving bearing capacity, size, weight, configuration, material and price.

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Kaydon special bearings offer you wide opportunities for compact design that may reduce the size of the equipment you need — providing substantial savings.

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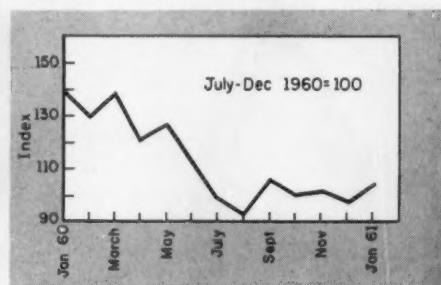
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World's highest capacity,
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the waning want-ads

Demand for technical manpower, which has been diminishing for over a year, continues to drop. The Engineer/Scientist Demand Index, compiled by Deutsch & Shea on the basis of recruitment advertising, shows only a few periods of slight upturn during a gradual decline since January of last year. Chart at right, in which the July-December, 1960 average = 100, shows a sub-index based on advertising in technical journals from January, 1960 through January, 1961.



computer count

The computer population explosion is emphasized by these figures: 4927 commercial digital computers were in use at the beginning of 1961; 6453 more are on order, to be delivered before the end of 1962. A computer census report in the April issue of *Data Processing* shows that the Federal government uses 540 of the machines; local governments, 130; universities, 138. The other 4119 are in finance, business, and industry. The report also points out that there are five times more computers now in use than in 1957.

gas-cooled reactors pull ahead

Gas-cooled, graphite-moderated plants account for nearly two-thirds of some 6,700,000 kw of nuclear plant capacity now in operation, being built, or contracted for in various parts of the world, according to Corwin L. Rickard of the General Atomic Div. of General Dynamics Corp. In pointing out the increased use of gas cooling for reactors, Mr. Rickard described its "almost spectacular" improvement in efficiency. Net plant efficiencies of approximately 40 per cent are predicted.

Venus on the beam

In an attempt to learn more about Venus for NASA, a tracking station in the Mohave Desert is directing radio signals at the planet during the two months when it is closest to Earth. The first transmission on March 10 was rewarded with reflected signals described as strong and clear after their 70-million-mile, 6½-minute round trip. Other radio signals have been bounced off Venus, but these were the first that were immediately detectable without elaborate analysis and processing. The radio-signal experiments will try to determine whether Venus spins on its axis and the speed of rotation, orientation of the planet's spin axis, and the nature of its surface.

cryogenic criticisms

Basic low-temperature performance data on 14 metals used in fuel valves and other critical components of missiles will be provided by research at Battelle Memorial Institute, Columbus, Ohio. A thorough knowledge of such properties is essential, according to Dr. Donald N. Gideon of Battelle, because the success of a missile shot can depend on whether a valve operates properly at temperatures of liquid fuels. To determine a metal's low-temperature fatigue properties, a 1.2 by 1.6-in. specimen, 0.020 to 0.080-in. thick, is evaluated in fully reversed plate-bending experiments at a rate of 5200 times a minute while immersed in liquid hydrogen. Each specimen is tested at -110, -320, and -423 F, as well as at room temperature.

the price of inexperience

An increase in starting salaries for technical and professional people does not result in similarly fattened paychecks for older employees, in most companies. A survey of 107 industry representatives by the Bureau of National Affairs shows that 59 per cent do not grant general increases when they raise starting rates, 38 per cent do, and 3 per cent have no definite policy. Larger firms tend to be more generous to the old hands—44 per cent give raises to "incumbents," compared to only 23 per cent of the smaller companies.

versatile power for space

Twenty-one million pounds of thrust from a cluster of seven rocket engines is suggested by Thiokol Chemical Corp. for the initial stage of a manned space vehicle. Reporting to NASA on its study of the economic feasibility of a super vehicle for space exploration, the company recommended development of a three-million-pound-thrust solid-fuel engine. The second stage would use three of the engines, and upper stages would be propelled by liquid-fuel engines—the most economical combination, according to Thiokol. The company estimates that development of the big solid-fuel engine would require three years, and that the over-all vehicle would be ready within five years. It could propel a 300,000-lb payload to orbital velocity, or 125,000 lb to escape velocity.

hybrid computer is quickest

A new type of computer—combining the analog's speed, ease of programming, and lower cost, and the digital's capacity for data storage and time-sharing of components—was put through its paces at the recent IRE show. The model 5800 DYSTAC (Dynamic Storage Analog Computation), developed by Computer Systems Inc., easily provided answers to complex problems in electronic-circuit optimization and aircraft and missile design, guidance, ballistics, and fuel consumption. It handles partial differential equations, roots, powers, advanced algebra, differential and integral calculus, and decimal fractions as easily as simple problems in addition.

*Vehicle designers have challenged
an unforgiving environment
to assure . . .*

Mobility at minus

60



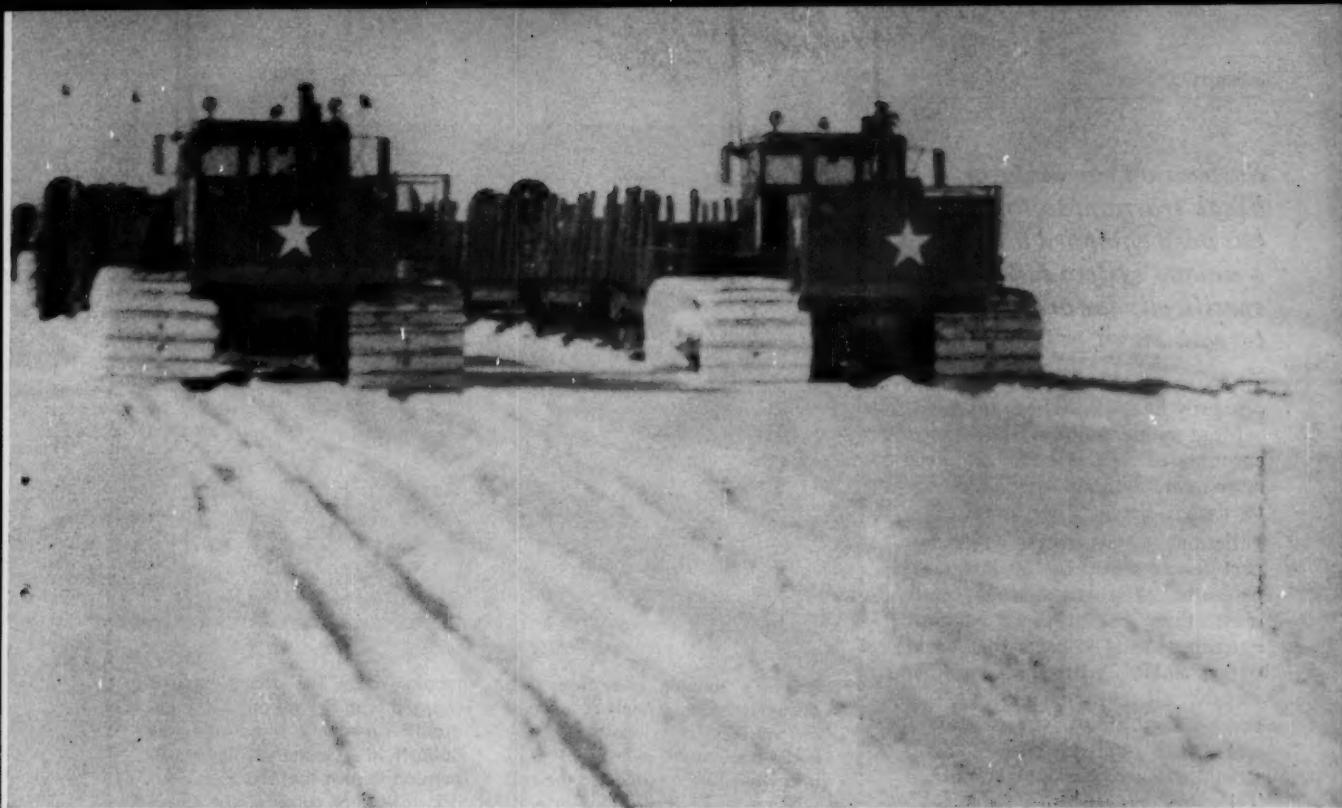
Polecat's track is built-up of 2024-T6 aluminum forgings mounted to fabric-reinforced belts. The bars are protected at the major wear areas by bolted-on steel pads: One at the point of contact with the ground, another at contact with the sprocket teeth. Each of the bars can support a static center load of 11,000 lb when supported on 34-in. centers. The bar is shaped so that on hard surfaces only the narrow center section contacts the ground. As terrain softens (with corresponding vehicle sinkage), more of the bar is brought into ground contact. This minimizes steering forces during much of the operation and greatly reduces the number of peak stresses on the bar during hard-ground operation (only large irregularities will cause the entire length of the bar to bridge). Shape of the bar also provides a female guide for the pneumatic road wheels. With this system it is necessary to provide very positive guiding at the sprocket and idler, and this has been done by running rigid metal flanges in the same female-guide depression to provide lateral positioning. The track is positioned axially by rubber-tired wheels also mounted to the full-floating drums at the idler and drive axles.



TEN years ago, the only moving things in northern Greenland were bears, foxes, a few dog teams, and the two-mile-thick icecap itself. Today, polar research groups are probing the earth's "last frontier" in vehicles that maintain 30 mph average speeds over some of the most difficult terrain in the world. Speeds of 100 mph are confidently being predicted for the future.

Things are going so well in the arctic, in fact, explorers have been heard to say that much of the adventure is gone. It is no longer common to abandon vehicles on the trail during every trip, regular schedules can be maintained, and the chance of finishing a run on foot has been virtually eliminated.

Why, then, further interest in designing for cold-weather mobility? Support of important military installations, like the big BMEWS base at Thule, is one reason. A second reason, put forward originally by Admiral Perry, is now echoed by numerous influential people: Perry called the inland ice of the arctic an "imperial highway" . . . a vast obstacle-free area with great transport potentiality. To capitalize on this idea, various governmental and military groups are sponsoring fur-



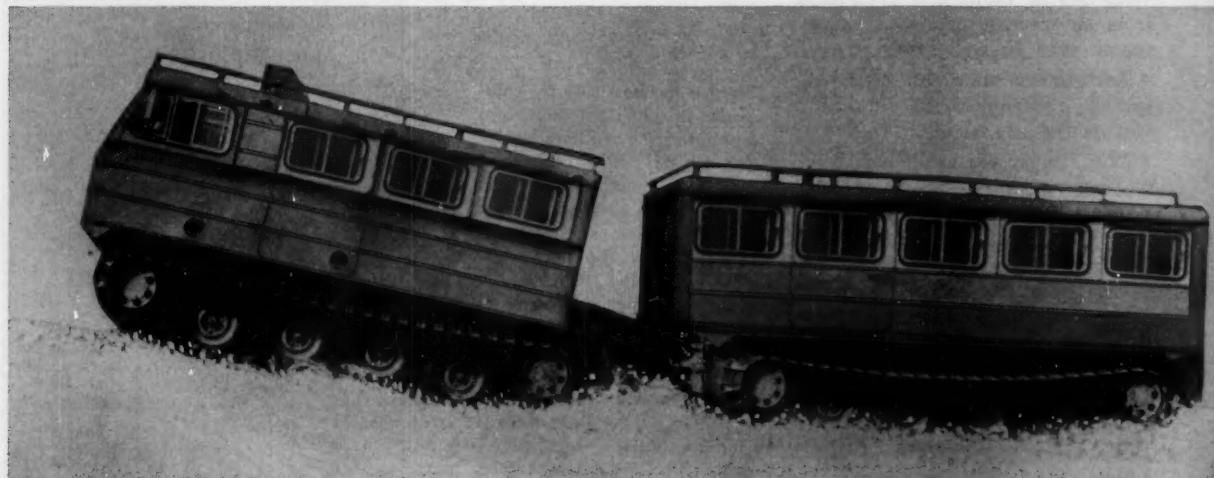
ther vehicle research efforts.

One of the leading research teams responsible for progress in arctic travel since 1951 is the firm of Wilson, Nuttall, Raimond Engineers Inc., Chestertown, Md. Members of the firm have designed many tracked vehicles for commercial and military use, including the Mark II Polecat described on these pages.

Mark II incorporates most of what is now known about cold-weather mobility and will enter arctic service this year for Army Corps of Engineers' Polar Research and Development Center.

From a performance standpoint, the internal-combustion engine (and the vehicle it powers) probably suffer more in the arctic environ-

ment than man does. The problem is not merely one of high lubricant viscosity vs. low battery efficiency, or poor fuel atomization, or the fact that at -50 F even with engine idling, the grease in driveline components will channel within minutes. These are environmental ills which have been known for years, and for which efficient remedies—



Polecat Mark II represents the current state-of-the-art in vehicles designed for arctic travel. It will carry 34 passengers plus a crew of two at speeds up to 30 mph. Previous tracked vehicles have occasionally averaged 12-mph, while huge wheeled vehicles plod along at 5 mph.

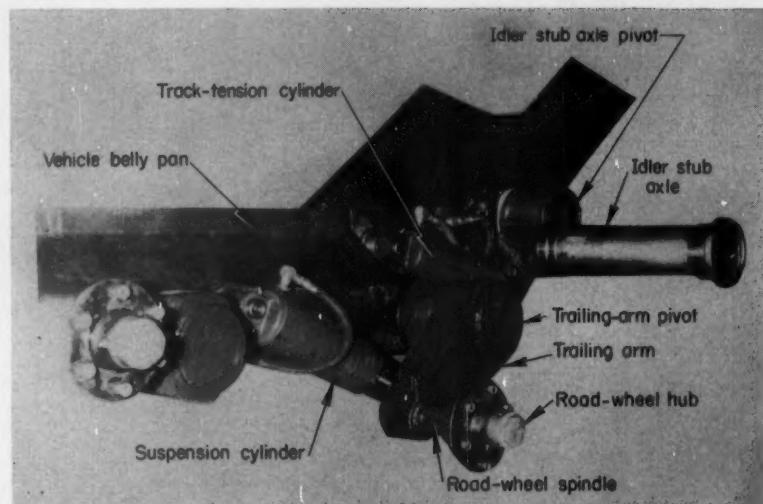
Suspension can make or break traction, so Polecat has been equipped with a unique system tailored specifically for arctic terrain . . .

primarily heat—have been invented.

More subtle problems have been encountered which have required, more than anything, strict adherence to design detail. For example:

- Ferrous metals exhibit great impact notch sensitivity at low temperatures. Highly stressed parts must thus be protected against notch-producing impacts that could trigger sudden brittle failures. Obviously, all parts should be well finished and free of stress concentrations originally. Use of high-strength steels such as Tri-Ten and T-1 have proved to be good insurance for cold-weather reliability.
- Hot cracks and micro cracks in improper welds also produce notch effects which can lead to brittle failure. Proper preheating, the use of austenitic welding rods with low hydrogen flux, and controlled cooling after welding help beat this problem.
- Fine particles of snow, like sand, can infiltrate very small openings and pack an entire compartment in a short time. Linkages and controls must be designed and located with this in mind, and everything from air cleaners to crew compartments must be well sealed.
- Instruments must be oiled with special low-temperature lubricants, just as the engine is.
- "O" rings, electrical insulation, weather stripping, shock mounts, and all similar flexing components must be made of special low-temperature elastomers. Rubber and many other flexible materials become brittle at arctic temperatures.
- Wheel bearings corrode due to condensation within the hubs unless protected by special lubricants.

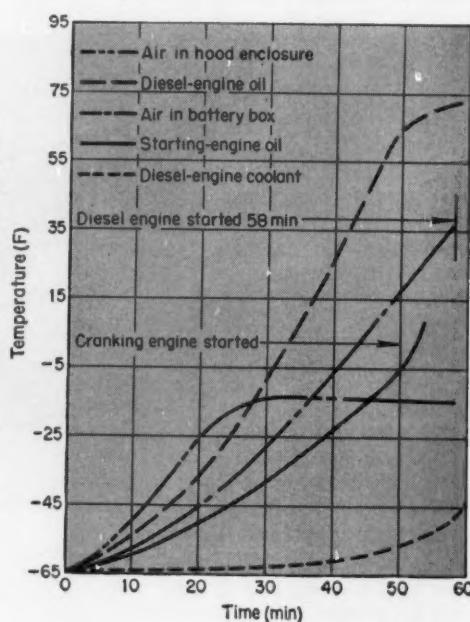
Human factors pose another critical area—minor inconveniences in normal circumstances become intolerable handicaps under arctic conditions. All vehicle components should be readily accessible, and all access openings should be large



Polecat's running gear uses big pneumatic road wheels suspended on trailing arms controlled by hydro-pneumatic cylinders. Tire and wheel are mounted to the hub which rides on the spindle extending from a welded box-section trailing arm. The trailing arm is affixed at its upper end to a threaded tube which engages a threaded trunnion extending from the vehicle belly pan. The tube also carries an arm which actuates the suspension cylinder, a special single acting hydraulic unit with a piston type accumulator within the

tubular rod. The accumulator is charged with dry nitrogen, the hydraulic cylinder is filled with MIL 5606 fluid. Geometry of the suspension is such that the characteristic resistance curve of the pneumatic spring is overcome by the toggle action of the actuating arm to produce a very desirable suspension action. An identical cylinder is used for the track tensioning, thus giving a sprung idler which has proved desirable. Total wheel travel of the suspension is 10 in. from rebound to full bump, unique for a tracked vehicle.

Heat is the best cure for cold-soak. Graph (right) illustrates normal start cycle from -65 F for an 831 cu in. naturally aspirated diesel engine with two-cylinder gasoline starting engine. Ether starting aids are used on both engines. 250,000 btu furnace-type gasoline heater discharges to plenum beneath the diesel engine and through ducts to warm the diesel crankcase, starting engine crankcase, and oil filters. Shutter on the radiator contains heated air within the insulated engine compartment.



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BUT NOT TO YOUR PAYROLL

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Although hydrofoils offer 100-mph speeds, some experts predict that an arctic "subway" will prevail . . .

enough for a heavily clothed man to use them efficiently. Hatches, covers, and doors should have fastenings easily managed by gloved hands. They should also be sufficiently sturdy to withstand the stresses incidental to freeing them after a freeze down.

Because many of the basic problems have been solved, future efforts in designing arctic vehicles will be largely concentrated on achieving higher speeds.

First attempts have already been made to capitalize on the wide-open space of the ice cap. A research vehicle, called the Keebird, has successfully tested the concept of "flying" on long narrow skis which cut just below the surface of the snow. Speed and ride limitations are thus divorced from the irregular wind-sculptured surface in the same manner that wave action is separated from a boat equipped with hydrofoils. Built by Wilson, Nuttal, Raimond, Keebird has achieved speeds in excess of 75 mph during tests. It points the way to future operational vehicles that will travel 100 mph.

According to WNR, the final long-range transport system calls for vehicles that go completely beneath the surface. The Snow Ice and Permafrost Research Establishment (SIPRE) is seriously studying snow as a construction material. A first project is Camp Century, the "City under Ice," which is now generating its power in a transportable nuclear reactor installed in a snow-roofed trench.

As a further outgrowth of the snow construction work, SIPRE and WNR are studying and testing methods for the production and roofing of cross-country vehicle tunnels. The objective is an all-weather, hard-surface "road," completely invisible beneath the surface of the 'cap. Minor problems remain to be solved, but the system is said to be entirely feasible.



Keebird, a 75-mph snow hydrofoil, forerunner of polar-express vehicles.



Tunneling offers important military advantages: An invisible roadway is established through which vehicles can travel immune to enemy infrared and radar.

VALUE ANALYSIS FACT SHEET

Formbrite Drawn Brass Parts

How to open finishing room bottlenecks and cut polishing costs up to 50%—produce stronger, more scratch-resistant parts—and get additional savings—with Formbrite, superfine-grain drawing brass.

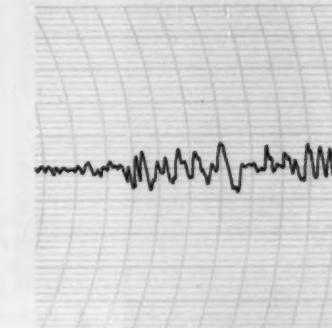
Very often in the production of drawn brass parts which are to be plated or lacquered, finishing costs are greater than those of all preceding operations—or even the cost of the metal. Under any circumstances, they are a high percentage of total costs.

Furthermore, parts go through the pressroom a lot faster than they can through the finishing room, creating bottlenecks in production.

ENLARGED SURFACE TRACES at the right prove that you can lick both cost and time problems with Formbrite®, Anaconda superfine-grain drawing brass. Savings in polishing costs reported by users run from 40 to 50%. These are net savings, as Formbrite costs no more than ordinary drawing brass.

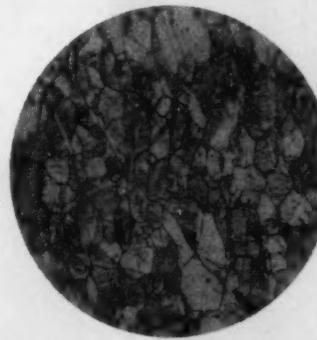
STRONGER, MORE SCRATCH RESISTANT. Formbrite is stronger, harder, springier than the usual drawing brasses in the same standard tempers, yet retains remarkable ductility for forming and drawing, and takes sharp, clean-cut ornamental die impressions. The harder surface means fewer rejects from scratching and marring during handling. In some instances, the superior strength and hardness of Formbrite make possible the use of a thinner gage metal, with an additional saving in material cost.

SIZES AND TEMPERS. Brass manufactured by the Formbrite method, with its special characteristic of superfine-grain structure, is supplied in standard Formbrite temper, half-hard, three-quarter-hard, hard, and extra-hard



Enlarged surface trace of Formbrite drawing brass (grain size, .005 mm) after 40% elongation. Surface smoothness after deformation is the test of a drawing brass's polishing characteristics. It is relatively easy to level these little hills on the surface of Formbrite. In many cases, users find they eliminate cutting operations altogether, need only a simple color buff.

Enlarged surface trace of standard drawing brass (grain size, .045 mm) after 40% elongation. This kind of roughness causes "orange peel" effect in the working of standard drawing brass. Smoothing such mountains down to the valleys takes considerable cutting.

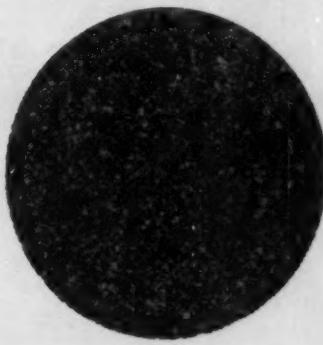


This is the microstructure, shown 75x, of the standard drawing brass used above.

tempers, and can be rolled in heavy coils to .004" in thickness by 24" wide, weighing 100 pounds per inch of width. The table below gives physical data and terminology for Formbrite tempers.

TERMINOLOGY FOR FORMBRITE TEMPERS

TENSILE STRENGTH LB. SQ. IN.		ROCKWELL B HARDNESS		DESIGNATION TO BE USED
MIN.	MAX.	MIN.	MAX.	
49,000	59,000	40	65	Yellow Brass—Formbrite
57,000	67,000	60	77	Half-hard Yellow Brass—Formbrite
64,000	74,000	72	82	Three-quarter-hard Yellow Brass—Formbrite
71,000	81,000	79	86	Hard Yellow Brass—Formbrite
83,000	92,000	85	91	Extra-hard Yellow Brass—Formbrite



This uniform superfine-grain structure of Formbrite, shown 75x, is produced by special procedures for rolling or drawing and annealing developed by Anaconda American Brass Company.

ALLOYS. In addition to 70-30 brass, the following Anaconda alloys also are produced by the Formbrite method: Yellow Brass-59, Gilding Brass-4, Commercial Bronze-14, Red Brass-24, and Low Brass-32.

TECHNICAL ASSISTANCE. For help in selecting the alloy and temper to handle your particular job—for a copy of Publication B-39 with more details about Formbrite—see your Anaconda representative. Or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

6145

FORMBRITE
Superfine-grain drawing brass
a product of
ANACONDA
Anaconda American Brass Company



ENGINEERING NEWS
PICTURE REPORT

Titanium aircraft wheel made by Goodyear Tire & Rubber Co., Akron, withstands 1000 F. Also, because of the material's low rate of heat conduction, the new wheel reduces the amount of heat normally transmitted from brakes to tires. Built for initial use on jet aircraft, the wheel has safety features that make it suitable for prop-driven aircraft as well, according to Goodyear. Among these features are corrosion resistance; lighter weight, therefore greater strength-to-weight ratio; and greater impact resistance, compared to magnesium or aluminum wheels.



A luxury sports sedan and compacts with sports-car-features are among the latest offerings in the automotive field. Two new Tempest coupes are built $\frac{1}{2}$ -in. lower than the original four-door sedan, and one has bucket seats in front. The "Three-Point-Eight" Jaguar is a five-passenger sedan, 180 $\frac{1}{4}$ in. long. It is powered by a 3.8-liter, twin-overhead-camshaft, dual-carburetor engine and goes 120 mph.



An intumescence coating proved its ability to protect rocket engine parts against blast damage in a test firing of a Titan I second-stage engine at the Aerojet-General liquid-rocket plant. Trailing edge of the ablative skirt of the thrust chamber was coated with Dyna-Therm D-65, a phosphate and boron chemical dispersion in a polyurethane binder. Heat of firing caused the light-colored material to foam and char, but the skirt remained undamaged. The coating's thermal conductivity is approximately 0.15. It was developed by Dyna-Therm Chemical Corp., Culver City, Calif.

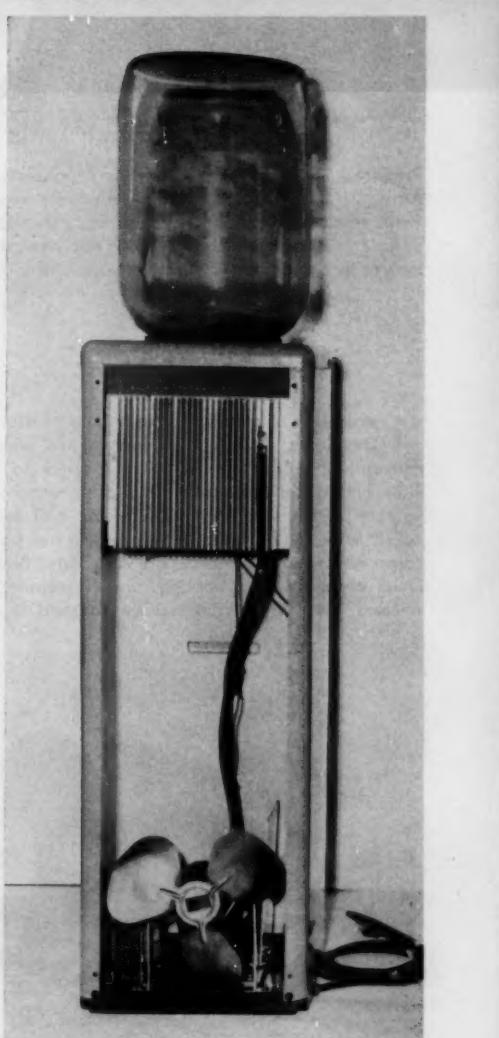
A do-it-yourself kit for prototype printed circuits makes it possible to lay out a circuit pattern on a Fotoceram grid board in 15 minutes. Boards are studded with 0.052-in. holes in a 1-in. grid. Made by Corning Glass Works, Corning, N. Y., the kit consists of two 3 by 5-in. copper-clad Fotoceram grid boards, liquid etching resist, vinyl resist tape, and ammonium persulfate crystals for making the etching solution. It costs \$8.95 and is being sold by Corning distributors.

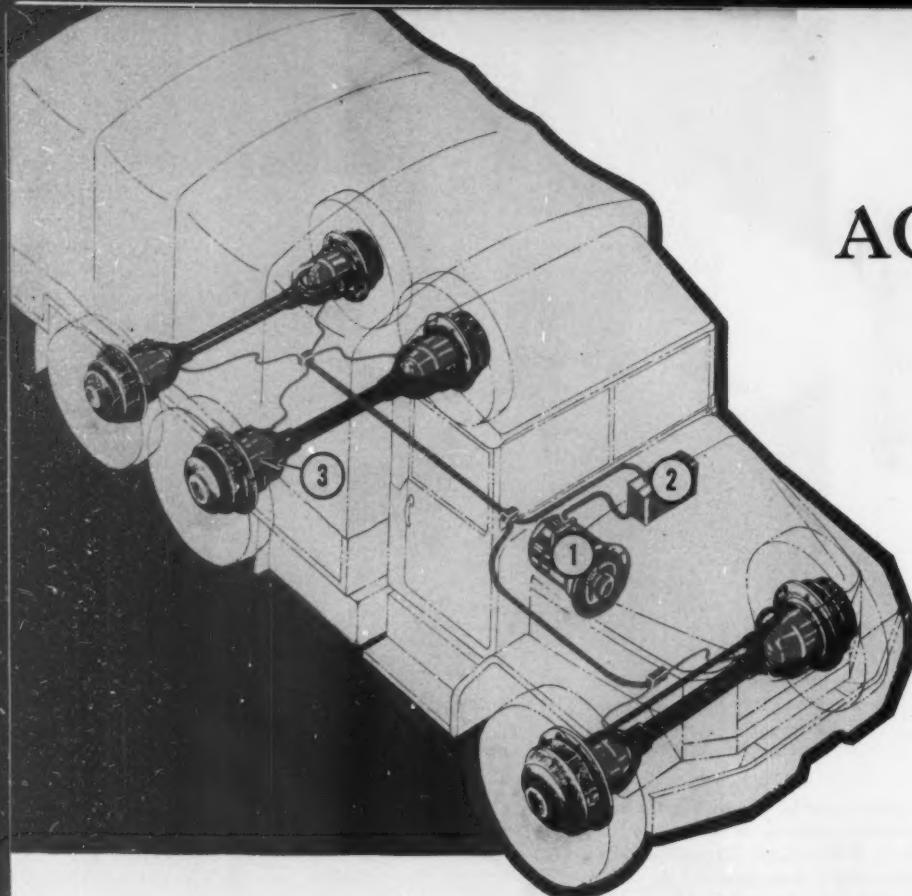


Thermoelectricity clears out the cabinet of a water cooler, the first thermoelectric appliance to be built on a production-line basis by Westinghouse Electric Corp. Elimination of the motor-driven compressor and the "network" heat-exchange system cuts down the volume of components to 25 per cent of the conventional cooler. The only moving parts in the new cooler are in the fan that dissipates heat drawn from the cooling elements.



Longer life and improved performance can be expected from radio and television tubes using a new heater-insulation coating announced by Radio Corp. of America. A "dark heater" wire—one with the new chemical coating—operates at a temperature 20 per cent lower than a conventional "white" electron tube heater. Ultimate tensile strength of the wire is increased 50 per cent, and internal stresses are reduced as much as 25 per cent by the lower operating temperature. The new coating (shown on heater at right in photo) can be used on any receiving tube.





AC-Powered Electric Wheel

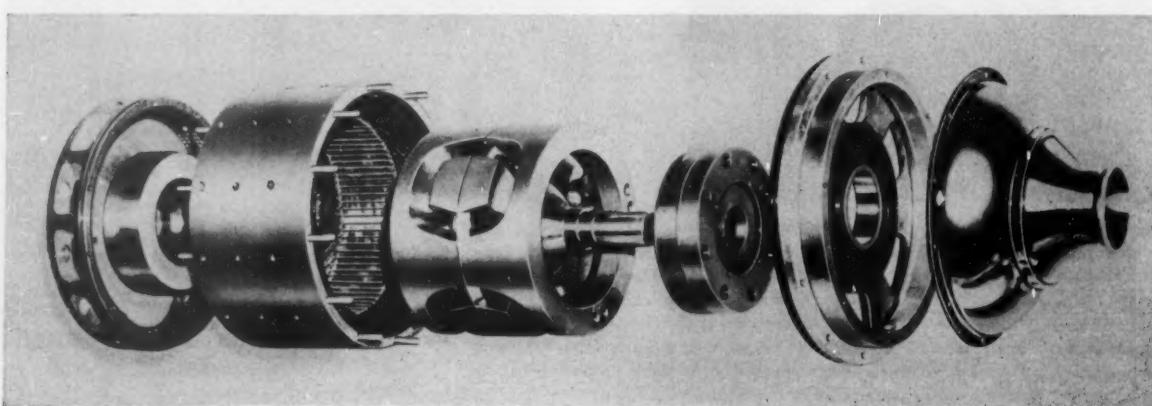
Proposed installation of the "ac transmission" in an Army 2½ ton 6 x 6 truck. Relatively small motors, with reduction gearing, would be mounted at each wheel. Concept of using ac is not new, but J & H system incorporates many refinements and improvements.

1 **Brushless alternator** is the source of electric power. Developed by Jack & Heintz, the device has a conventional armature winding located in the stator slots and a bobbin-wound dc exciting winding attached to each of the end barrels. The rotor is of solid metallic construction and carries no windings. The only wearing components in the device are bearings. Because there is no need for rotor cooling, and no rotating seals are needed, the alternator is readily adapted to oil cooling.

HEAVY, complex transmission systems may have kept the lightweight gas turbine from assuming more prominence as a prime mover in land and amphibious vehicles.

Conventional devices for converting output power of the high-speed (up to 40,000 rpm) turbine into usable wheel power (at about 100 rpm for large vehicles) have included multi-shift mechanical transmissions, torque converters, and dc traction-motor drives. Dc drives provide favorable operating characteristics, but often weigh more than their mechanical counterparts. Also, certain dc components—brushes, commutators, etc.—present special maintenance problems.

Engineering effort, therefore, is being directed toward ac propulsion equipment. A complete ac transmission-



Light-weight system based on aircraft-type components would be powered by a turbine-driven alternator

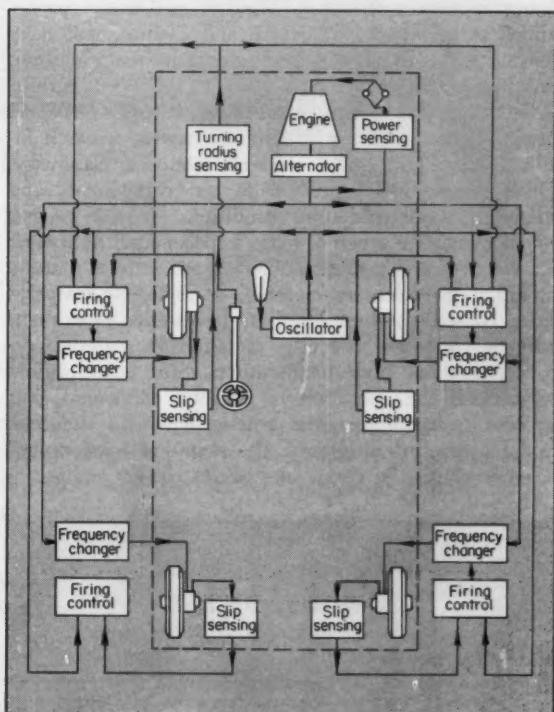
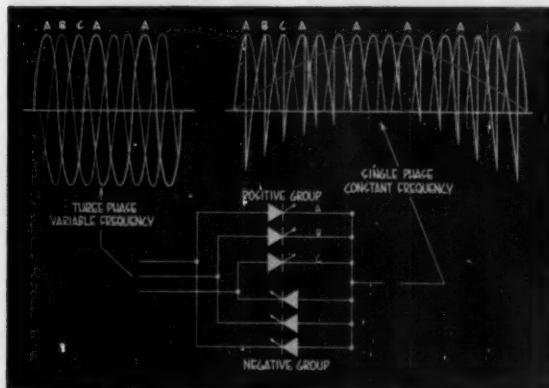


3 Wheel hubs contain ac traction motors (squirrel-cage induction), which are reportedly smaller and lighter than comparable dc units. Since speed of the ac motor is controlled by frequency, wheel slippage is less than with dc systems (where motor and wheel torque are controlled).

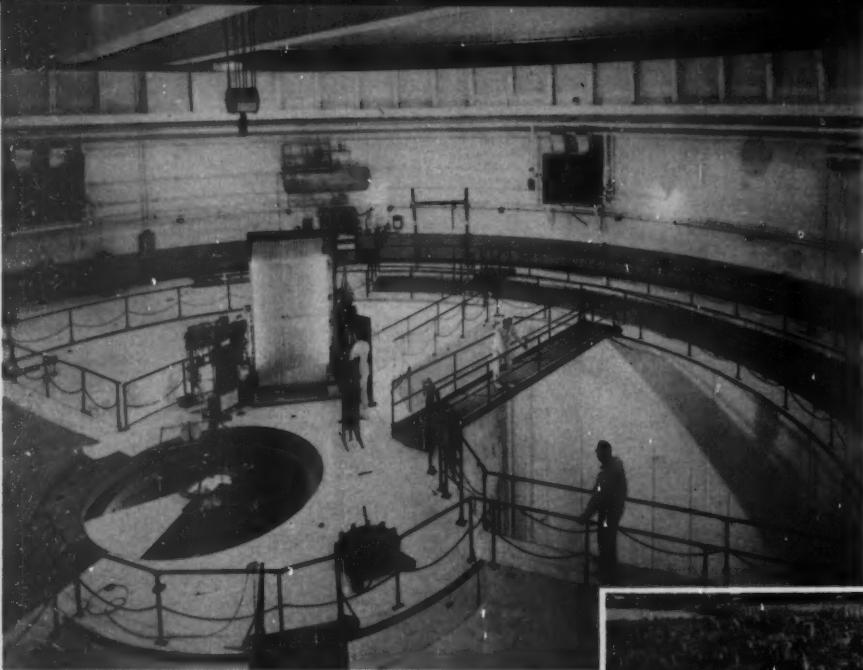
drive system, developed for Army's Ordnance Tank-Automotive Command by Jack & Heintz Inc., Cleveland, shows promise of solving the turbine/vehicle compatibility problem. The system consists of three basic elements: 1. AC generator (alternator), 2. Frequency changer, 3. Induction motors.

The alternator is connected directly to the turbine and is capable of handling the turbine's full output. Generator output is fed to a unique black box, called a frequency changer, which distributes power to the motorized wheels. Driver of the vehicle controls speed by adjusting an oscillator in the frequency changer.

Outstanding advantage of the J & H system is that it combines the simplicity, freedom from maintenance, and long life of an ac system with the almost ideal characteristics of the dc system.



2 Ac driveline (schematic) is built around the frequency changer, a static switching device that converts variable-frequency ac from the turbine-alternator set into controlled-frequency ac for the traction motors. Controlled-frequency wave (left) is actually "fabricated" from small pieces of numerous higher frequency alternator waves.



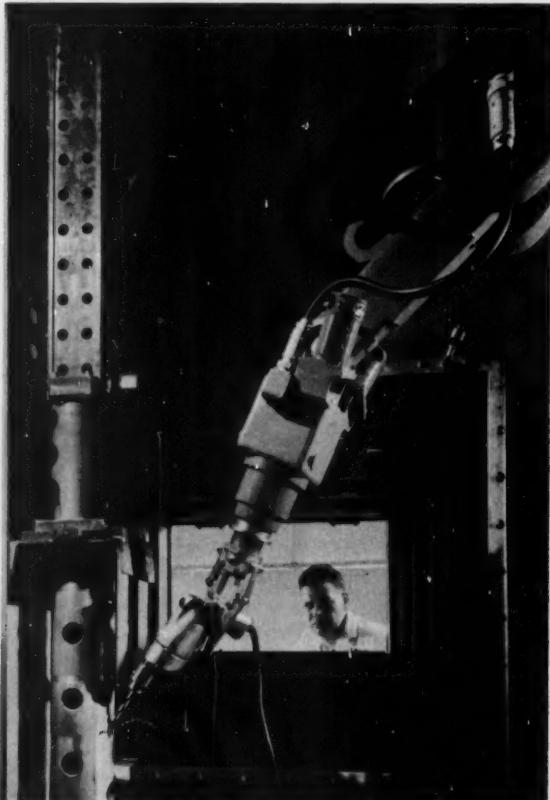
"Lily-pad" (left), capping the reactor pressure tank, is centered over a 70-ft diameter pool of water 25 ft deep. Reactor core, mounted 21 ft below surface, consists of a 3 x 9 array of fuel elements designed for maximum thermal power of 60 megawatts. Entire Plum Brook facility (below) will be staffed by approximately 100 personnel under the direction of NASA's Lewis Research Center, Cleveland.

NASA's Plum Brook Reactor: Prelude to Nuclear Power in Space

As the big chemical space boosters near completion, development of nuclear-powered upper staging is being rapidly accelerated. Most of the heavy probes aimed at deep space by Saturn and Centaur will carry reactors as a primary source of electricity for propulsion and instrumentation.

To keep pace with quickening schedules, NASA began operation this month of its newest research facility. The Plum Brook research reactor at Sandusky, Ohio, is designed especially to test components and materials under radiation conditions. It will pose a tough hurdle for much of today's spacebound hardware.

One of the first experiments on schedule is a study of radiation effects on materials at cryogenic temperatures (propellant feed lines, etc.). Another experiment will determine the effects of radiation on material corrosion rates at high temperatures. Still other studies will check the operation of sensitive electronic gear exposed to radiation. The reactor will also simulate, under controlled conditions, the radiation environment of powerplants like *Rover*, the nuclear-rocket engine.



Old hand at nuclear research, the mechanical substitute (right) will perform most of the physical tasks involved in testing materials and components. Main reactor control console (above) is under direction of a licensed operator.

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Circle 217 on Page 19

Stainless-Clad Aluminum Rhenium-Molybdenum Alloys

**Four Metals Pair-Up
To Form Two Useful
New Materials**

MOLECULAR bonding of aluminum sheet to stainless steel—accomplished on a production basis for the first time—will broaden the uses of the two metals in a number of commercial and industrial applications. Introduced by Fairmont Aluminum Co., Fairmont, W. Va., the new material combines the desirable characteristics of stainless (resistance to corrosion and staining, hard finish, strength) with those of aluminum (light weight, heat conductivity, formability).

Although initial production of stainless-clad aluminum will go to manufacturers of cooking utensils, the material shows promise of replacing certain automotive parts that are normally made of stainless only, and in a number of missile applications.

According to Fairmont officials, there are no limitations on the gauge of the clad sheet and no fixed-content ratio of stainless to aluminum. A typical sheet 0.05 in. thick would be made up of 0.009 in. stainless and 0.041 in. aluminum. The combination would have approximately

half the weight of a similar 0.05-in.-thick solid stainless-steel sheet.

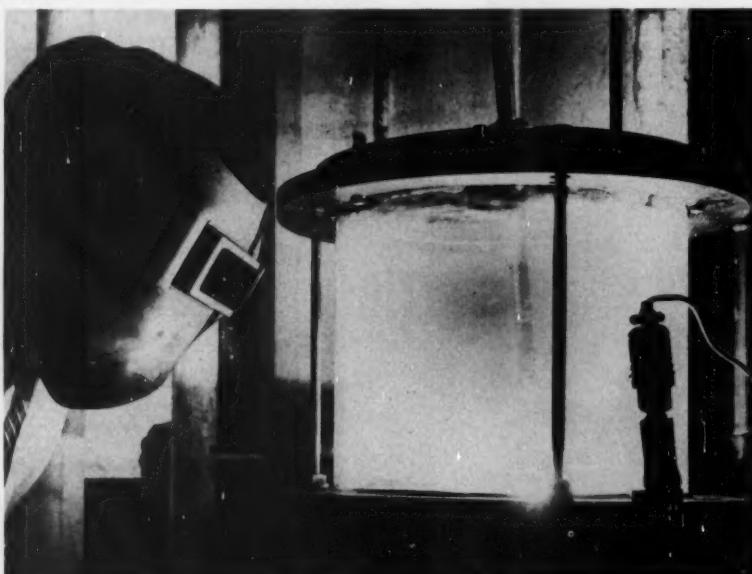
Tested by several of the nation's leading cooking-utensil manufacturers, the clad aluminum has reportedly shown excellent metallurgical characteristics during various fabricating operations—deep drawing, stamping, trimming, beading, and spinning. It also performs well under arc welding, stud and spot welding, brazing, coining, and usual surface-finishing operations.

Ready with Re-Mo

First commercial production of rhenium-molybdenum alloys—by Chase Brass & Copper Co., Waterbury, Conn.—is expected to enhance many products in the aerospace, electrical, and electronic fields. Research tests reported by Chase, indicate that typical Re-Mo alloys are superior to either metal in the pure state.

Made available in quantity for the first time last year, rhenium is an extremely dense metal with a melting point of 5756 F. It has a good

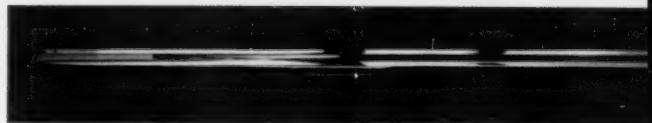
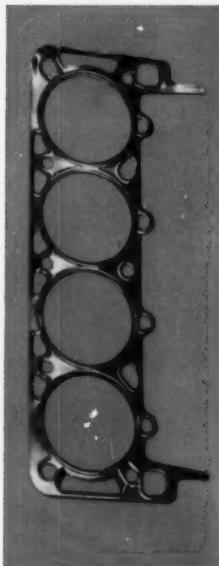
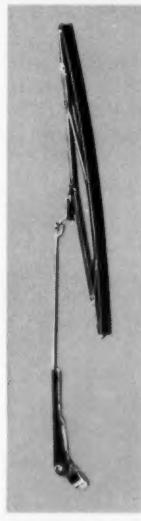
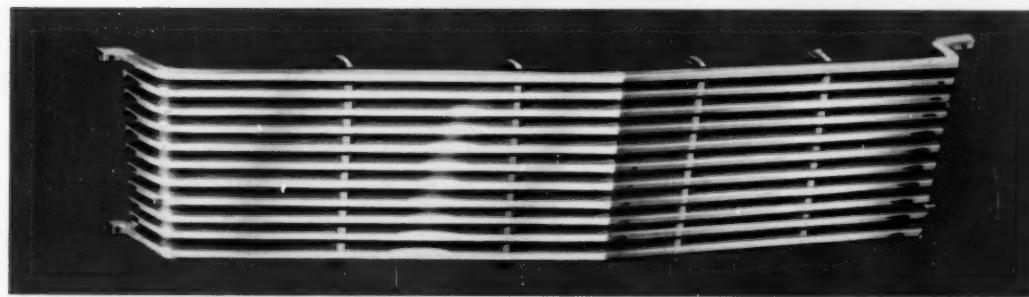
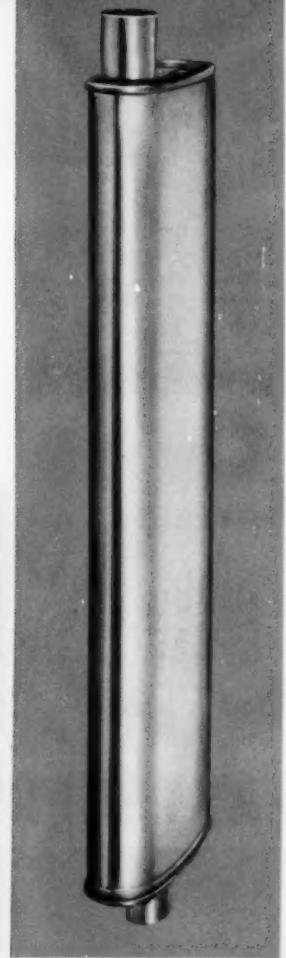
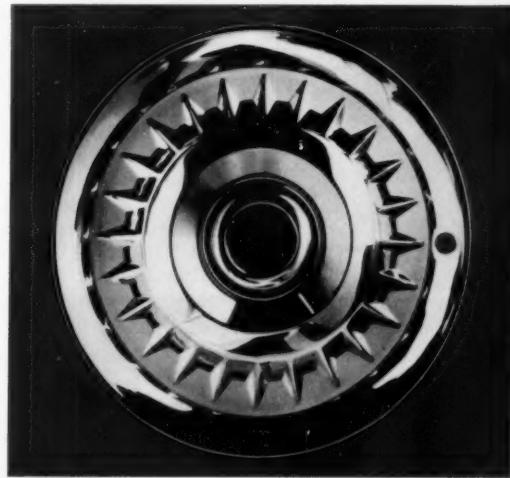
(Please turn to Page 41)



Re-Mo compacts are melted into test bars in a tungsten-arc furnace. Alloys have better mechanical properties than either rhenium or molybdenum in the pure state.

Circle 218 on Page 19→

Automotive Horizons and Allegheny Stainless...

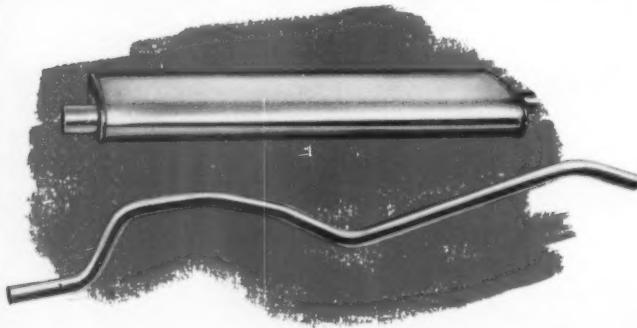


STAINLESS...a growing force in today's automotive design

The continued improvement in stainless steels and the increased demand of today's motorists for attractively styled automobiles that stay attractive have combined to throw open the door to more and more stainless automo-

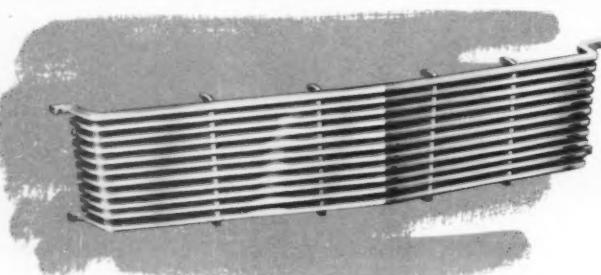
tive applications. And longer warranties are pushing the trend to stainless. Here are some of the places you're most likely to find Allegheny Stainless on cars today... or maybe tomorrow.

Mufflers and Tailpipes



Nothing enhances the beautiful lines of an automobile like sparkling brightwork, and nothing is a bigger chore to care for if it begins to spot and pit, rust or peel. With Allegheny Stainless trim, the original beauty is a beauty forever, stainless clear through and as corrosion resistant in its old age as the day it came off the line. Highly formable, gleaming bright, protective and dent resistant...stainless steel.

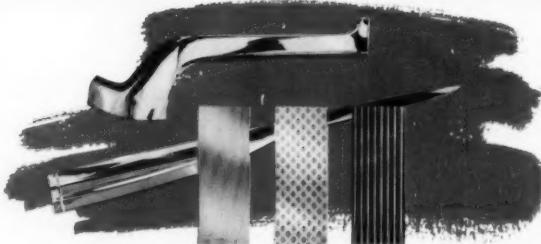
Grilles



Wheel covers and hubcaps demand a variety of metal characteristics and some are almost mutually incompatible...springiness, formability, dent resistance, brightness, corrosion resistance, scratch resistance, dimensional stability, stiffness...and more. Only one metal can come close to meeting all these requirements...stainless steel.

It's long been admitted by automotive people that a car shouldn't have one of its components operating in a hot, highly-corrosive environment without real corrosion resistance built into that part. But it's been a cost problem. Allegheny Ludlum's answer to the muffler problem is MF-1, a special, economical, ferritic stainless steel with good formability and corrosion resistance. Mufflers made from MF-1 have corrosion resistance built in. The stainless is solid. There will be mufflers made entirely from MF-1; others with MF-1 in the corrosion-susceptible internal wraps and baffles only. In either case, this corrosion resistance won't chip, peel, or burn off.

Trim



Nothing establishes the appearance of a car as much as the "expression on its face"...its front end-grille design. And nothing has more to contribute to the beauty, prestige, and crisp styling of the grille design than stainless steel. Allegheny Stainless in bar form, tubing, strip or patterned sheet lends itself to economical fabrication techniques...roll forming, expanded metal, spot welding...all important in any fabrication with as much resultant waste as present grille forming techniques. Automotive engineers, using some of these newer processes, are re-evaluating stainless.

Hubcaps and Wheel Covers



STAINLESS...both on and over the automotive horizon

More and more stainless steel will appear on the cars of tomorrow. Everything points to it...today's conditions require it, so will tomorrow's. There's a definite trend to longer warranty periods. Competition will probably cause these warranties to be extended, and extended yet again. Parts simply must last longer to make these warranties possible.

There's also a trend toward less owner-maintenance, such as sealed lubrication systems, sealed engine coolant and automatic air conditioning systems, self-adjusting brakes, and the like. Design features such as these will continue. Again, competition will probably force the extension of such systems, and their inevitable elaboration.

Both trends lead to increased use of Allegheny Stainless. When parts just have to stand up in warranty, the call is for stainless. And when less owner-maintenance develops, the corrosion resistance and foolproof characteristics of stainless begin to pay off. Such hidden applications as fuel tanks, floor pans, surge tanks, radiator systems, etc., are already receiving a good, hard look from engineers as future stainless applications.

Other requirements are advanced by design problems and improvements in automotive interiors. Gleaming, durable stainless steel makes a sales feature of the constant, close-up scrutiny of even the most discriminating auto passenger. It stands up under constant handling, scuffing and lack of polishing and provides the modern automotive interior with the ornamental brilliance that is uniquely stainless.

Characteristic of stainless, as well, is its remarkable ability to withstand elevated temperatures for long periods of time, and to resist corrosive environments under such conditions. As early developmental work has shown, this admirably fits it for service on the numerous anti-smog devices now vying for official recognition. With service temperatures as high as 1800 F, with lead oxide, sulfur, catalysts, and other chemical corrosion a factor, no other material can be actively considered aside from a stainless, heat-resisting steel.

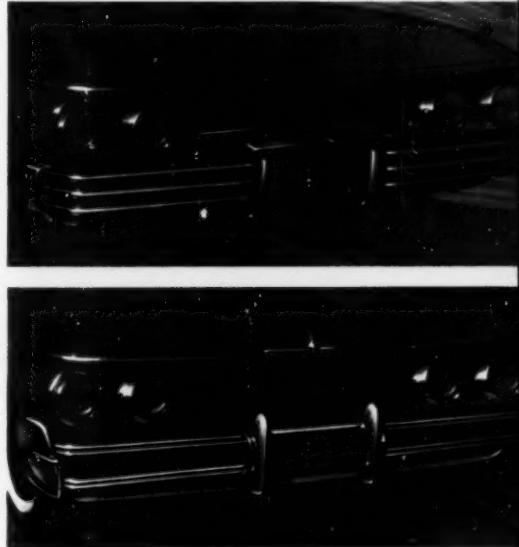
These are just a few thoughts on how Allegheny Stainless and the automotive designers will be working for motoring enjoyment...tomorrow or the next day.

Bumpers

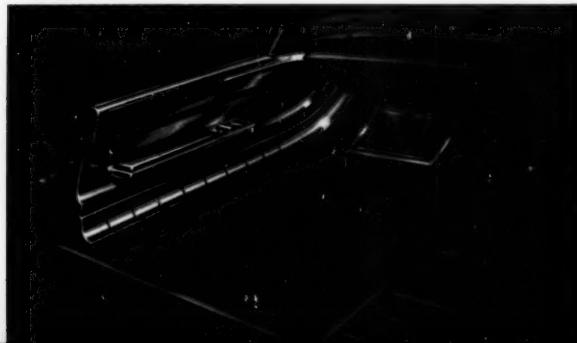
Possibly the most exciting design possibilities involve the front and rear of the modern automobile and the need for bumpers. Designers are faced with the task of integrating a massive section of metal into an overall design concept. Stainless steel can play a very great part in this effort, from both the esthetic and structural standpoints.

One interesting bumper technique is the fabricated bar bumper of stainless steel. Solid stainless bars offer an unmatched combination of beauty and strength, are easily formed, and may be worked into a variety of front-end designs featuring floating grilles and fabricated bumper guards. Stainless bars are repairable, by straightening, welding, buffing...all relatively simple operations.

Or, the protection and beauty of stainless steel may be obtained in a bumper with a metallurgically-bonded stainless cladding over the baser, underlying metal. Cladding offers the same exterior corrosion resistance and durable beauty as solid stainless designs. It won't scrape, peel, or rust. And, for maximum impact strength, and equal protection with lighter cross sections, some of the high strength stainless grades offer most interesting avenues for exploration.



Interiors



hidden

The Value of Stainless

in Automotive Design...

IN DESIGN

...to designers, stainless steel has a highly utilitarian character. Designers feel better about working with its honest nobility. They prefer its reliability, its mathematical predictability, its strength, the look and feel of it, and its uniquely masculine character. It's a designer's metal.

Ask a housewife about this strong and handsome metal ... about its useful life, its strength, its corrosion resistance. She'll be able to tell you...she lives with it daily and sees it everywhere. She knows its beauty and prestige-building appeal, its dollar-value economy.

But aside from these obvious advantages, stainless steel has hidden values for those who really know it well, an added desirability based on reasons both functional and esthetic...practical and personal.

IN STYLING

...to stylists, the rich luster and high prestige of stainless steel provide an irresistible creative challenge. They are intrigued by the limitless possibilities offered by its variety of textured surfaces and finishes, its ease of forming, bending, shaping. It's an expressive metal... a stylist's metal.

IN MARKETING

...salesmen and marketing men know the value of stainless in automotive design. They know a customer's reaction to it. They know the universal appeal of stainless, the built-in customer acceptance based on its unqualified success in kitchen and other home appliances, in sporting goods, jewelry, and cutlery. It helps sell. It's a salesman's metal... a marketing metal.



ALLEGHENY LUDLUM STEEL CORPORATION

General Headquarters: Oliver Building, Pittsburgh 22, Pa.



EVERY FORM OF STAINLESS EVERY HELP IN USING IT

(Continued from Page 36)

combination of strength and ductility, plus excellent electrical characteristics, even at high temperatures. Typical applications include grids, heaters, and cathode supports for electronic tubes; thermocouples, and welding filler rod. Its big drawback is high cost.

Molybdenum, now a familiar structural material in missiles, is also used in electronic tubes. Its melting point is 2600 C. Molybdenum's handicap: It becomes embrittled in the recrystallized condition at temperatures below approximately 20 C.

Alloying of the two metals brings out the best characteristics of both. The alloys have better mechanical properties than either metal, cost less

than pure rhenium. High-temperature strength exceeds that of molybdenum, and very good ductility is retained down to the cryogenic temperature range (-450 F) without evidence of embrittlement.

Excellent ductility of Re-Mo permits fabrication and forming in either a cold or warm condition. Cold drawing is particularly important in the fabrication of components for electronic tubes—it assures much better surface quality, less danger of contamination, and generally improved properties of wire following initial warm "break-down" operations.

Re-Mo in rod, wire and strip are now available from Chase in 50 Re-50 Mo and 40 Re-60 Mo (weight/ per cent) alloys.

Meetings and Shows

April 23-26

American Society of Mechanical Engineers. Metals Engineering Conference to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

April 24-26

Association of Iron and Steel Engineers. Spring Conference to be held at the Jefferson Hotel, St. Louis. Further information is available from AISE, 1010 Empire Bldg., Pittsburgh 22, Pa.

April 24-26

Metal Powder Industries Federation. 17th Annual Technical Meeting and Powder Metallurgy Show to be held at the Hotel Sheraton-Cleveland, Cleveland. Additional information is available from MPIF, 60 E. 42nd St., New York 17, N. Y.

April 26-27

High - Temperature Materials Conference to be held at the Pick-Carter Hotel, Cleveland. Sponsor is the Cleveland section of the American Institute of Mining, Metallurgical, and Petroleum Engineers, in co-operation with the

High Temperature Alloys Committee and the Refractory Metals Committee of the Institute of Metals Div. of the Metallurgical Society. Further information is available from the Metallurgical Society of AIME, 29 West 39th St., New York 18, N. Y.

April 26-28

Institute of Radio Engineers. 1961 Conference of the Seventh Region to be held at the Hotel Westward Ho, Phoenix, Ariz. Further information can be obtained from Everett Eberhard, Motorola Military Electronics Div., 8201 E. McDowell Rd., Scottsdale, Ariz.

April 26-28

Society of the Plastics Industry Inc. Annual Western Section Conference to be held at the Hotel del Coronado, Coronado, Calif. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

May 2-3

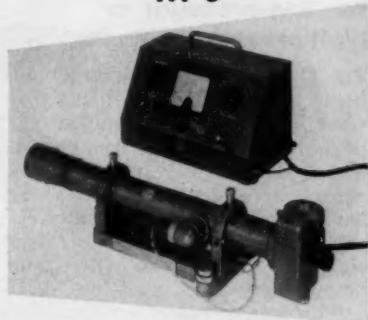
Lead Industries Association. Annual Meeting to be held at the Drake Hotel, Chicago. Additional information can be obtained from association headquarters, 292 Madison Ave., New York 17, N. Y.

May 3-6

American Helicopter Society. Annual National Forum to be held

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to 0.05 second

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reduces operating time
increases accuracy
and convenience

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Circle 219 on Page 19

New, compact PRESSURE CONTROL VALVE

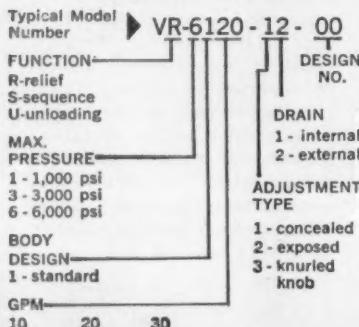


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high-pressure circuits

The Dynex pilot-operated, hydraulically balanced pressure control valve is designed for simplified application and low-cost installation. Functions efficiently at high or low pressures. Withstands severe shock loads. This new design features excellent characteristics of low override, low override with increasing volume, and quick reseating.

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Select the configuration that suits your needs



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Phone: Pewaukee 691-0300

HYDRAULIC PUMPS VALVES MOTORS CYLINDERS CIRCUITS

Circle 220 on Page 19

ENGINEERING NEWS

at the Sheraton-Park Hotel, Washington, D. C. Further information can be obtained from society headquarters, 2 E. 64th St., New York 21, N. Y.

May 8-12—

American Foundrymen's Society. Castings Congress and Exposition to be held at Brooks Hall and the Civic Auditorium, San Francisco. Further information can be obtained from AFS headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 8-12—

National Industrial Production Show of Canada to be held at the Industry and Coliseum buildings, Canadian National Exhibition Park, Toronto. The Canadian section of the American Society of Mechanical Engineers is among the sponsors. Additional information on the show is available from E. M. Wilcox Ltd., 19 Melinda St., Toronto, Canada.

May 9-11—

Western Joint Computer Conference to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from conference headquarters, 721 N. La Brea Ave., Los Angeles 38, Calif.

May 9-12—

American Society of Mechanical Engineers. Production Engineering Div. Conference to be held at the Royal York Hotel, Toronto. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

May 10-12—

Society for Experimental Stress Analysis. Spring Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Further information can be obtained from SESA headquarters, 21 Bridge Square, Westport, Conn.

May 14-17—

National Fluid Power Association. Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from association headquarters, 1618 Orrington Ave., Evanston, Ill.

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Circle 221 on Page 19

May 15-16—

American Institute of Electrical Engineers. Packaging Industry Technical Conference to be held at the New Ocean House, Swampscott, Mass. Additional information is available from AIEE, 33 W. 39th St., New York 18, N. Y.

May 21-23—

Fluid Controls Institute Inc. Annual Meeting to be held at the Cloister, Sea Island, Ga. Further information is available from FCI headquarters, P. O. Box 667, Pompano Beach, Fla.

May 22-24—

National Telemetering Conference to be held at the Hotel Morrison, Chicago. Sponsors are Institute of the Aerospace Sciences, Institute of Radio Engineers, Instrument Society of America, American Rocket Society, and American Institute of Electrical Engineers. Additional information can be obtained from IAS, 2 E. 64th St., New York 21, N. Y.

May 22-25—

Design Engineering Show and Conference to be held at Cobo Hall, Detroit. Conference is sponsored by the Machine Design Div. of ASME. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 22-26—

American Society of Tool and Manufacturing Engineers. Conven-

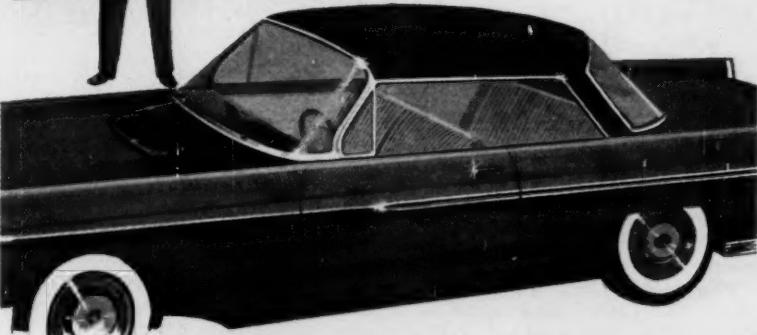


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FIRST to guarantee—unconditionally—that its product would successfully survive the Automotive Industry's severe tests for brightness and corrosion-resistance . . . tests the product did pass, a performance that has caused thirteen competitors to try to copy Wallingford's unique method, a method that remains unmatched; and a performance that convinced one major automotive company to specify Wallingford Type 201 Bright Annealed exclusively!

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And ask us how Wallingford Bright Annealed can enhance the beauty of your product, endow it with high corrosion resistance, and greatly reduce your finishing costs. Describe your application and we'll provide specific recommendations.

Progress in Metals Since 1922



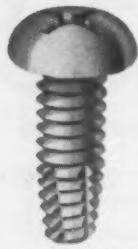
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Used as a measure of evaluating thread-cutting screws, it proves that P-K Screws average 108% better working qualities than competitive types tested. Here's what this means to you: (1) stronger assemblies because of high resistance to thread failure, (2) less wear on driving tool, less operator fatigue through easier driving of screw, (3) reduced salvage and costly downtime problems due to greater in-place efficiency. Whatever the material, whatever the requirement, there's a P-K Thread-Cutting Screw just right for you! Write for your copy of Bulletin 2d containing full details on how the Function Factor Formula lowers assembly costs.

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...combines advantages of the five thread-cutting flutes of the Type F screw with the coarse pitch and widely spaced threads of the P-K Type B. It distributes cutting pressure evenly, lets chips fall to bottom of the hole, prevents cracking of the material.

...an improved tapping screw developed for use in Nylon. Functions as a combination thread cutting-and-forming screw, cutting a small amount of Nylon to allow full diameter of the threads to form. Can be readily removed and replaced without stripping or galling.

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*Patent Pending

†U.S. Patent 2,350,346

ENGINEERING NEWS

tion and Tool Exposition to be held at the Coliseum, New York. Additional information is available from ASTME headquarters, 10700 Puritan Ave., Detroit 38, Mich.

June 4-8—

American Nuclear Society. Annual Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information can be obtained from O. J. DuTemple, 86 E. Randolph St., Chicago 1, Ill.

June 4-9—

Society of Automotive Engineers Inc. Summer Meeting to be held at the Chase-Park Plaza Hotel, St. Louis. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Short Courses and Symposia

April 30-May 4—

Aero-Space Instrumentation Symposium, sponsored by Instrument Society of America, to be held at the Adolphus Hotel, Dallas. Further information is available from W. J. Gabriel, Group Engineer, Convair Div., General Dynamics Corp., Ft. Worth, Texas.

May 8-9—

Lubrication Symposium, sponsored by American Society of Mechanical Engineers, to be held at the Deauville, Miami Beach, Fla. Additional information is available from ASME Meetings Dept., 29 West 39th St., New York 18, N. Y.

May 8-10—

Fourth National Power Instrumentation Symposium, sponsored by Instrument Society of America, to be held at the La Salle Hotel, Chicago. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 9—

Technical Conference on Plastics in the Automotive Industry, sponsored by the Detroit section of the Society of Plastics Engineers Inc., in co-operation with SPE Plastics in the Automotive Industry Professional Activity Group. Additional information

tion can be obtained from John A. McPherson, Underground Products Inc., 12801 Inkster St., Livonia, Mich.

May 9-10—

Engineering Institute on Product Development to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

May 10-12—

Symposium on Pulp and Paper Instrumentation to be held at the Northland Hotel, Green Bay, Wis. Sponsors are the Instrument Society of America and the Technical Association of the Pulp and Paper Industry. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 19-20—

Design and Drafting Seminar, sponsored by the American Institute for Design and Drafting, to be held at Oklahoma State University, Stillwater, Okla. The program will cover such subjects as standards, training of design and drafting personnel, microfilming, reproductions, and photodrawings. Additional information is available from American Institute for Design and Drafting, 18465 James Couzens Highway, Detroit 35, Mich.

May 22-24—

National Symposium on Global Communications (Globecom V), to be held at the Sherman Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from IRE, 1 E. 79th St., New York 21, N. Y.

May 23-24—

Engineering Institute on Direct Energy-Conversion Systems to be held at the University of Wisconsin. Further information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

May 25-26—

Engineering Institute on Plastic



PLUS PROTECTION AGAINST OVERLOAD

Maxitorq

overload release clutches

Designers and builders have found MAXITORQ Overload Release Clutches the ideal way to provide dependable protection against overload conditions.

Unlike such devices as shear pins, the MAXITORQ Overload Release Clutch requires no disassembly or replacement after functioning. Once the cause of overload is removed or corrected, the machine may be re-started at once. Furthermore, MAXITORQ Overload Release Clutches may be adjusted for pre-determined overload protection.

In addition, users enjoy the proved advantages of the MAXITORQ Floating Disc Clutch...smooth, positive engagement and release...“floating” neutral with no drag or heating...easy manual adjustment.

We will be glad to give you the benefit of our long and successful experience in clutch and brake design; the overload release clutches are only one of many advanced MAXITORQ developments in both manual and electrically operated applications. Ask for literature, or outline your problem...write Dept. MD.

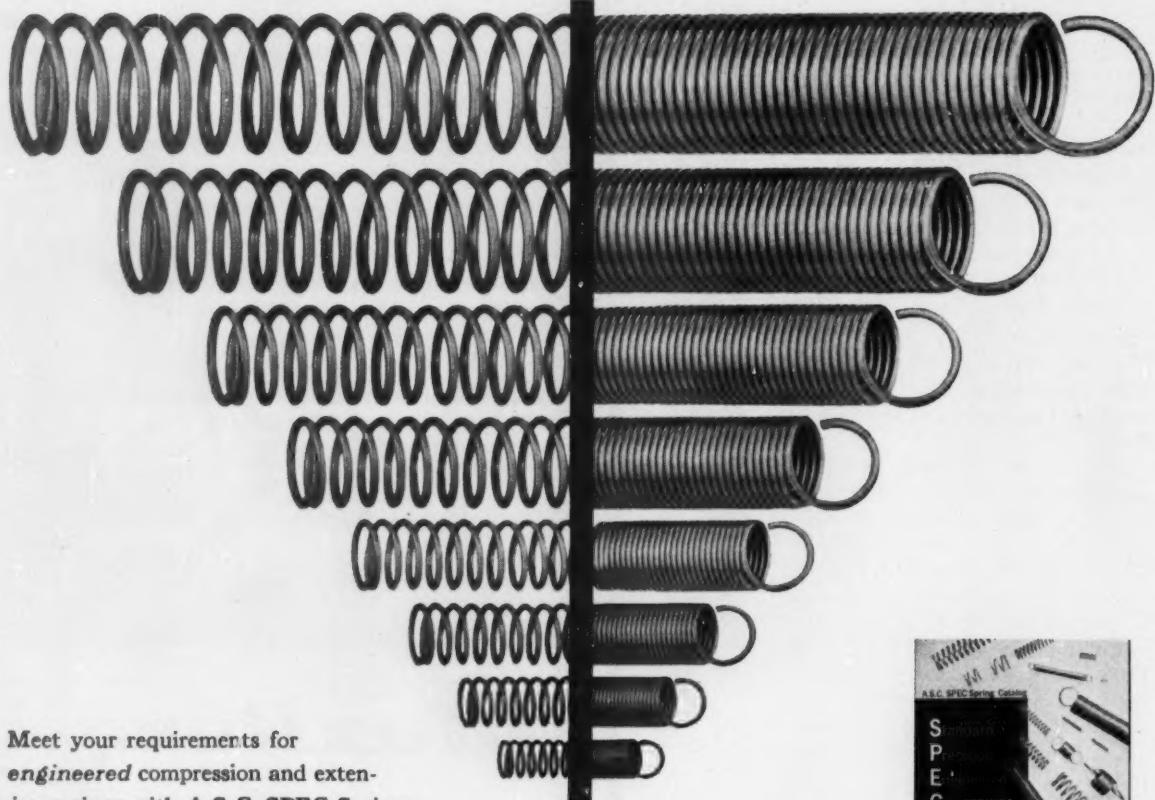


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Raymond Manufacturing Division, Corry, Penna.
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Cleveland Sales Office, Cleveland, Ohio

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B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Mattoon, Ill.

Milwaukee Division, Milwaukee, Wis.

Seaboard Pacific Division, Gardena, Calif.

Films to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

May 29-June 10—

Advanced Techniques of Programming Digital Systems-Mathematics, short course to be held at the University of California, Los Angeles. Course will deal with available techniques of programming and controlling digital systems, new research in the field of computer science, and new trends and problems arising both from new tendencies in the logical design of computer systems and from applications of digital systems to new fields. Further information is available from H. L. Tallman, Physical Sciences Extension, Room 6501 Engineering Bldg. II, University of California, Los Angeles 24, Calif.

June 8-9—

Engineering Institute on Practical Heat-Treating Fundamentals to be held at the University of Wisconsin. Further information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

June 11-16—

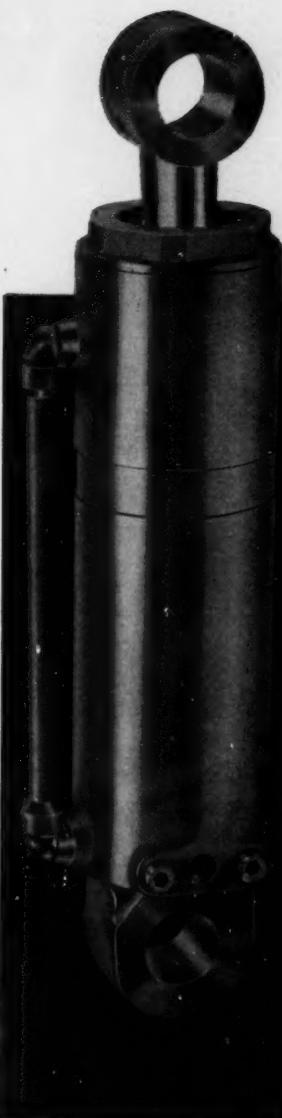
Seminar on Electrical Contacts to be held at Pennsylvania State University. Theory and practice in electrical contacts, including static contacts and commutation, and arcs and arcing contacts, will be covered. Additional information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

June 11-23—

Short Course on Solid-State Mechanics to be held at Pennsylvania State University. Major emphasis of the course will be on discussions of recently developed methods for evaluation and interpretation of stress-strain properties and the use of these procedures in design. Further information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

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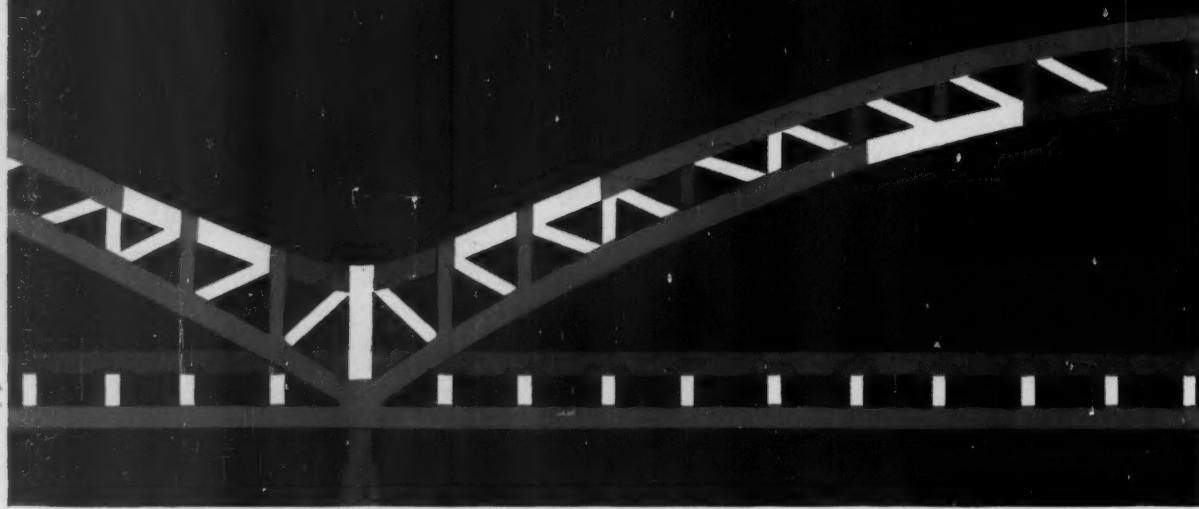
INTEGRITY • CHARACTER • QUALITY

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design steels used for efficiency and



Sketch of one span of the two-span bridge showing where it was most efficient to take advantage of the high yield strength provided by steels such as USS "T-1" Steel (in red), USS TRI-TEN High-Strength Low-Alloy Steel (in white), A7 and A373 Structural Carbon Steel (in gray). Louisville-New Albany Bridge

The new double-deck, two-span, tied-arch bridge spanning the Ohio River between Louisville, Kentucky, and New Albany, Indiana, should be extremely interesting to bridge designers and engineers.

Designed by the consulting firm of Hazelet & Erdal, this bridge is another fine example of the application of heat-treated constructional alloy steel, high-strength low-alloy and structural carbon steels to provide the desired strength at the least weight and lowest cost. A total of 7,641 tons of steel were used in the two 800-foot spans and the approaches.

Because much of this bridge was shop welded, the excellent welding properties of USS Design Steels played an important part in their selection. The weldable, constructional alloy USS "T-1" and high strength TRI-TEN Steels both permitted the design engineers to obtain considerable savings in the amount of steel needed, resulting in a substantial reduction in the total cost of

the structure. The saving in steel tonnage reduced dead weight enough to effect still further savings by reduced loads on individual truss members, piers, and foundations.

All of the tie and most of the highly stressed upper and lower chords and some verticals were made of 100,000 psi yield strength heat-treated constructional alloy steel. Approximately 1,500 tons of USS "T-1" Constructional Alloy Steel were used.

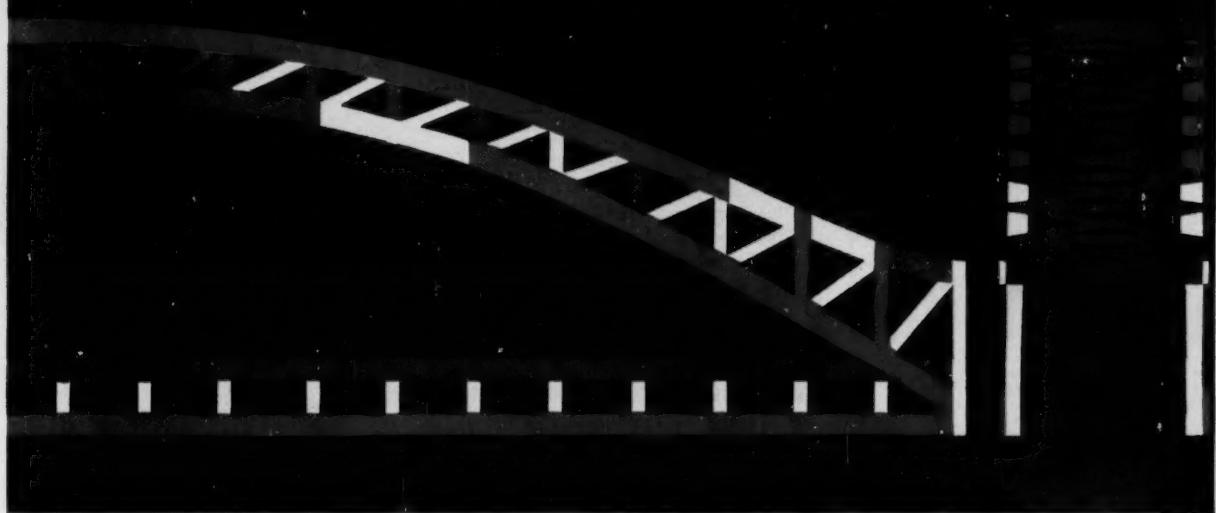
Most of the diagonals, some of the top and bottom chords and approach trusses called for 50,000 psi high-strength low-alloy ASTM A242 steel. USS TRI-TEN Steel—1,535 tons of it—was used for these applications. (USS TRI-TEN Steel can also meet specification ASTM A441.)

United States Steel also furnished 1,100 tons of ASTM A373 and 1,550 tons of ASTM A7 structural carbon steel, used in the lesser stressed members of the bridge and approaches.



This mark tells you a product is made of modern, dependable Steel

economy in Louisville-New Albany Bridge



was designed by Hazelet & Erdal, Consulting Engineers, Louisville, Kentucky, for the State Highway Department of Indiana and Kentucky Department of Highways. Fabricator: The R. C. Mahon Co., Detroit, Michigan. Erector: John F. Beasley Construction Co., Dallas, Texas (Sub-contractor to Mahon).

Two other USS High Strength Steels have been widely used for bridges—USS MAN-TEN ASTM A440 and USS COR-TEN Steels. Both have a 50,000 psi minimum yield point. USS COR-TEN Steel offers outstanding resistance to atmospheric corrosion and superior paint adherence qualities. It is a natural choice for riveted structures in corrosive areas. USS MAN-TEN ASTM A440 Steel is the lowest priced of our High Strength Steels and is generally used for riveted structures. Recently introduced, USS "T-1" Type A Steel is the newest member of our famous family of constructional alloy steels and offers, at the same strength level as "T-1" Steel, a more economical grade for applications 1" thick and under. For more information on any of these USS Design Steels, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS Steels for bridge design

	PSI Min. yield
Structural Carbon Steel (A373).....	32,000
Structural Carbon Steel (A7).....	33,000
Structural Carbon Steel (A36).....	36,000
USS COR-TEN High Strength Steel.....	50,000
USS MAN-TEN (A440) High Strength Steel.....	50,000
USS TRI-TEN (A441) High Strength Steel.....	50,000
USS "T-1" Constructional Alloy Steel.....	100,000

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel, San Francisco • National Tube, Pittsburgh • Tennessee Coal & Iron, Fairfield, Alabama • United States Steel Supply, Steel Service Centers
United States Steel Export Company



United States Steel

USS, "T-1", COR-TEN, TRI-TEN and MAN-TEN are registered trademarks

INTERNAL PRESSURE VS. EFFECTIVE SEALING

Internal pressure creates two forces which can cause leakage in a gasketed joint. Proper flange design and correct selection of gasket materials can overcome these forces.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

The pressure of confined liquids or gases acts against a gasket in two ways, as shown in figure 1.

1. Hydrostatic end force. This is proportional to the internal pressure and

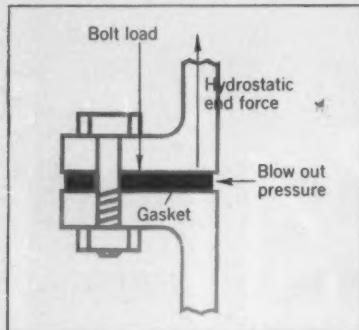


Figure 1. How internal pressure acts on a gasketed joint.

tends to move the flanges apart. As this occurs, the load on the gasket is reduced and leakage can result.

2. Blowout pressure. The sealed liquid or gas exerts direct pressure on

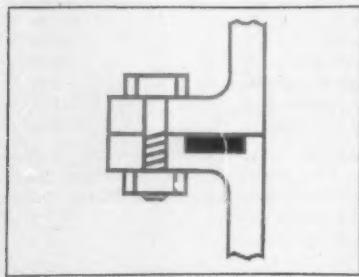


Figure 2. Flange design which confines gasket helps minimize blowout pressure.

the inside perimeter of the gasket. If this pressure is high enough, it will force the gasket out of the joint and leaks will occur.

These forces are usually associated with relatively high internal pressures. Studies at Armstrong Research and Development Center show, however, that pressures substantially less than 100 psi can cause leakage in some assemblies. (The Deflectometer shown in figure 3 is one tool used by Armstrong research engineers to measure flange deflection caused by internal pressure.)

Where internal pressures are involved, it is especially important to consider the joint as a unit. The flange design, the gasket material, and the temperature at the gasket line should all be considered in relation to each other.

The obvious first step is to be sure that flanges are sufficiently rigid to impose the required unit load on the gasket. The number of bolts, their size, their spacing, and their torque values are other factors related to flange loading which must be considered.

The second step is the evaluation of the gasket material to be used. High unit loads dictate the choice of a material that will not extrude or rupture under high pressures. This usually means a dense cellulose fiber or asbestos fiber material.

Several compositions suitable for service under high flange loads are

available in the Armstrong Accopac line of beater-saturated gasket materials.

Where a compressible material such as cork-and-rubber is to be used, a flange design which confines the gasket,

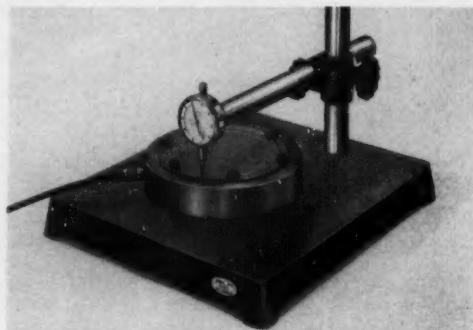


Figure 3. This Armstrong developed Deflectometer measures effect of 70 psi internal pressure in this stamped flange. Leak-producing deflections of .007" were detected at center point between bolts.

as in figure 2, will also help overcome blowout pressure.

A more complete discussion on the effect of internal pressure and other problems of gasket design, selection, and performance is included in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book.

Address Armstrong Cork Company, Industrial Division, 7104 Dean Street, Lancaster, Pennsylvania.



Armstrong GASKET MATERIALS



WHY STOCK DC CONTACTORS AND RELAYS?

... when you can assemble more than 100 devices from General Electric "building-block" components

There's no need to carry a large inventory of d-c contactors and relays . . . just to be sure you have the correct device when you want it!

"Building-block" design of General Electric contactors and relays permits you to assemble more than 100 different devices—right in your own plant—from a stock of as few as a dozen standard components.

G.E.'s "universal" contact block is the building unit for all types of contactors and relays. Choice of standard frame-and-coil assembly with proper combination of contact blocks and standard assembly kit permits the variation in devices to meet your specific application requirements.

Three complete contactor lines and six relay lines—for general-purpose,

mill-duty, overload, and timing functions—can be assembled using this unique approach.

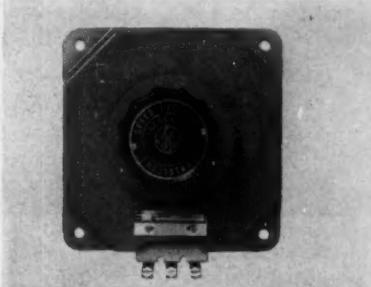
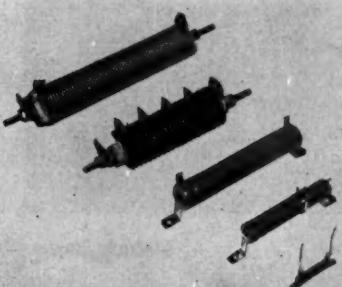
Rely on General Electric for all components—General Electric also has complete lines of plate rheostats and resistors. For additional information, contact your General Electric Sales Representative, or mail the coupon below. *Industry Control Department, Salem, Va.*

GENERAL ELECTRIC

Circle 228 on Page 19

Resistors—vitreous-enamelled and wire- and ribbon-wound types from 5 to 1210 watts. Fixed, slide-wire, or tapped types available.

Plate-type rheostats—windings are completely encased in metal to give longer and more reliable service for any application.



To: Section A784-31
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

- GEA-6621—D-c contactors and relays
- GEA-6592—Resistors
- GEA-6474—Plate-type field rheostats

Name _____

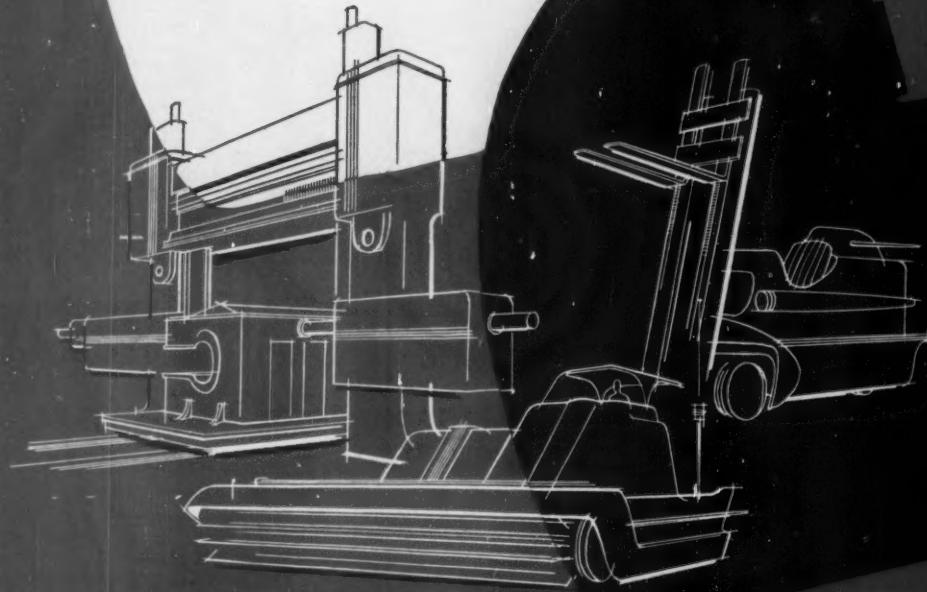
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Whatever
the shape of your future product-
McGill can help you now
with your bearing needs



■ The shape of things to come may or may not be known to us now, but we can be pretty sure many industrial machines and related equipment will look and operate differently from today's versions — also there will be those products not even existing today. They will put new demands on bearings — in shape, speed, capacity, space saving, accuracy, reliability and simplified product assembly. All new products must have a beginning — a research and development stage when components must be designed, built and tested in progressively improved prototypes. This is the time to take advantage of McGill engineering experience with thousands of proven applications using needle type roller bearings and cam followers — and special ball and roller bearings to precision specifications. McGill application engineers can help you design in greater bearing efficiency earlier with savings in time and expense. Call them in to work with you and for you — *at the beginning*.

Write for McGill Brochure No. 660, a bulletin of facilities and abilities. It explains how we can help you on your bearing application problems in the early stages of product research and development.

ELIMINATE
UNNECESSARY
ASSEMBLY
COSTS
with



*Replace improvised
units with readily
available precision
cam followers.*

McGILL®
CAMROL® BEARINGS

CF (Cam Follower) SERIES

The original and still unsurpassed anti-friction roller bearing cam-follower bearing that adds efficiency at less cost to cam actuated, track and support roller applications. Built with full roller complement and integral stud, the CF series design provides high radial capacity and shock load protection in a compact roller with its own shaft. Easily applied and available in roller diameters of $\frac{1}{2}$ " to 4".

SCF SERIES.

Sealed to keep contamination out and lubricant in. It is dimensionally interchangeable with the CF bearings. A turned groove in the center of the outer raceway bore provides a permanent lubricant reservoir to approach life-time lubrication requirements. Can be easily re-lubricated.

CYR (Cam Yoke Roller) SERIES

The CYR series increases the adaptability of the CF bearing to all types of automatic machinery involving cam action or controlled-motion machine parts that require guide or support rollers. An inner ring replaces the stud for cam yoke roller mountings.

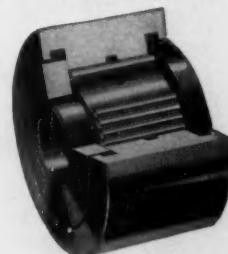
SCYR SERIES

This series provides a fully sealed Cam Yoke Roller type bearing. It is dimensionally interchangeable with the CYR bearings.

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

for the ultimate in:

- RADIAL CAPACITY
- SHOCK RESISTANCE
- SPACE ECONOMY



SCYR SERIES
(sealed)

Write for Catalog No. 52-A for full information on McGill's needle roller bearings and cam followers. Ask about recommendations for high precision special ball and roller bearings.



engineered electrical products

McGILL®
precision needle roller bearings

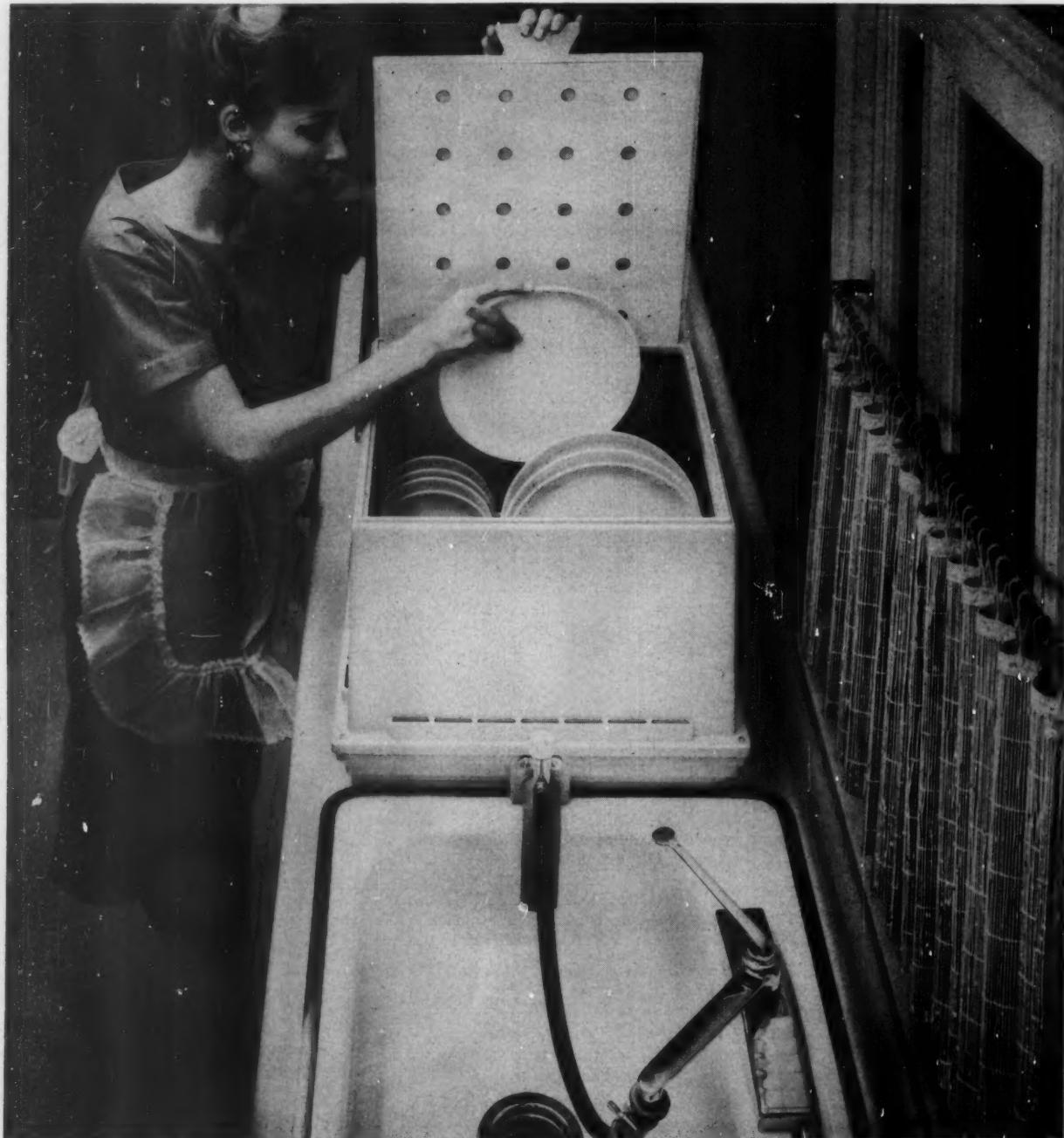


PLASTIC DESIGN IDEAS THAT MAY GIVE YOU AN IDEA

Portable dishwasher powered by kitchen tap

This 11-pound, portable dishwasher developed by Spaulding Industries, Inc., Chicago, Illinois, needs no power other than water pressure from a tap. Just set it on the sink, attach its hose to a faucet, and turn on the water. It washes and rinses completely in only 6-8 minutes.

The base, case and lid are molded from heat-resistant, high-impact DYLENE® polystyrene. The one-piece DYLENE base and lid have intricately molded vents that circulate cool air that dries dishes in a matter of minutes. DYLENE plastic is easy to mold in any permanent color, size or design. It won't flake, chip, peel or mar surfaces, and it's unaffected by harsh detergents and scalding hot water.





Foam plastic liner muffles disposer noises

Designers at In-Sink-Erator Manufacturing Company knew they could increase sales of this new Gold Comet garbage disposer if they could make it work quieter. So they placed a molded liner of DYLITE® expandable polystyrene inside the unit. This rigid foam plastic muffles noises as the unit shreds food wastes down the kitchen drain.

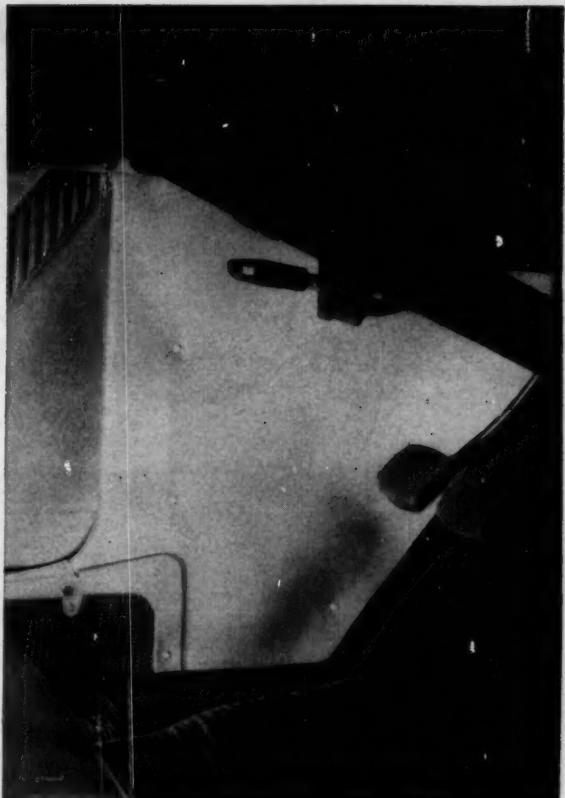
DYLITE is strong, lightweight, water and vapor-resistant. It can be molded to almost any size, shape or color. This low-cost plastic is ideally suited for a wide variety of applications in protective packaging, low temperature insulation, flotation and refrigeration. DYLITE parts molded by: Stevens Plastics Products, Hebron, Illinois.



Trash cans that won't rattle, rattle or corrode

Because it's polyethylene, these trash cans resist acids, alkalies, rust and corrosion, and even rough handling won't dent, chip or peel them. They're molded from durable DYLITE® polyethylene and available in beautiful permanent colors. Each trash can has a molded lid that locks tight and prevents spilling.

Koppers has a wide range of polyethylenes for almost any application. They are available in densities ranging from .914 to .953 gm./ml. By varying density, molders or design engineers can get varying degrees of stiffness, heat distortion and tensile strength. Trash cans molded for Sears Roebuck by G. A. T. X., Chicago, Illinois.



Plastic side cowls protect car interiors

Ford Motor Company now uses SUPER DYLAN® high-density polyethylene for interior side cowls on all their Falcon, Comet, Mercury, Thunderbird and Ford models. These cowls have replaced painted hardboard and fabric lacing. They last longer, look better, install easier.

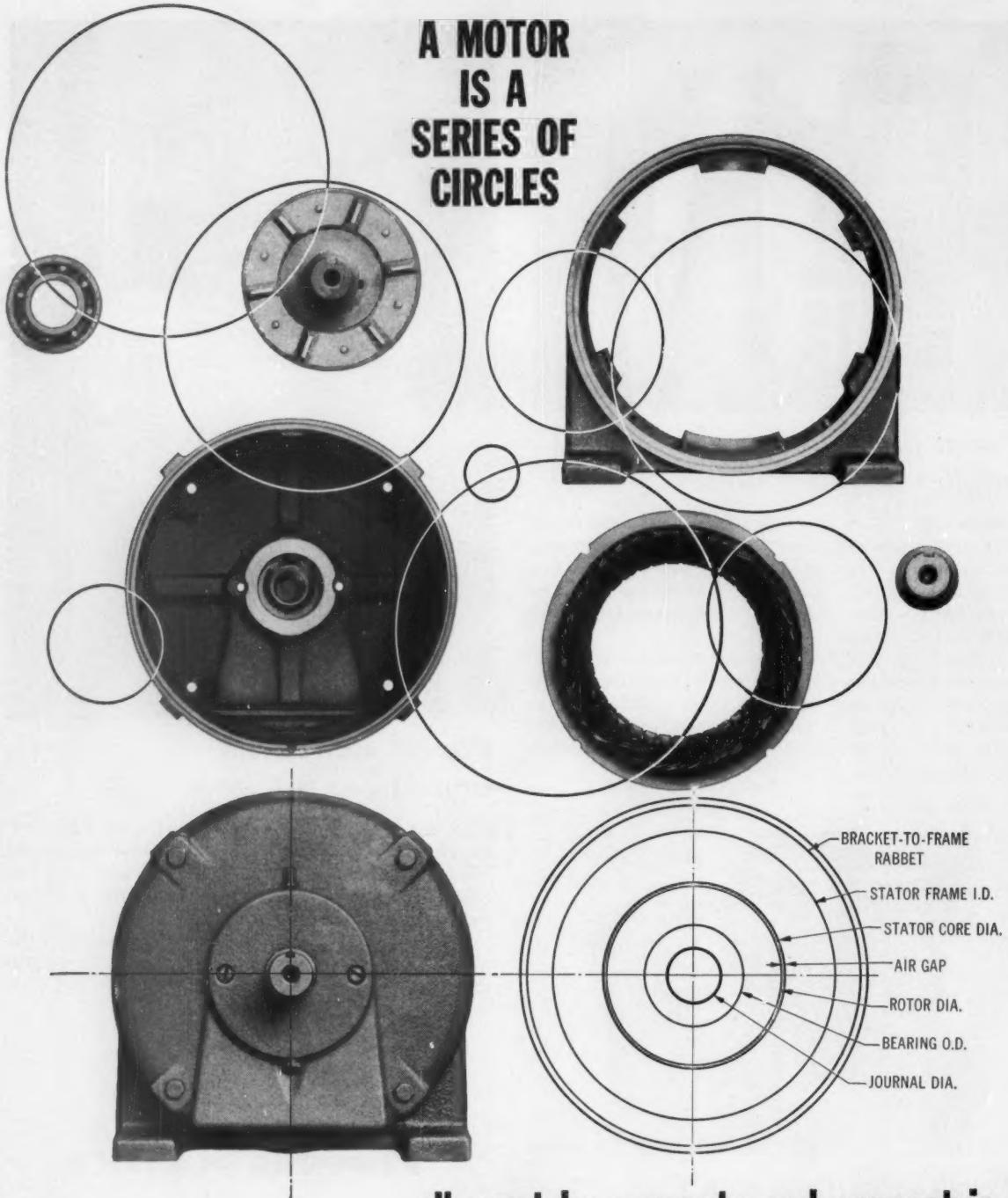
SUPER DYLAN side cowls won't scuff, crack, chip or peel. They won't absorb water so they don't warp or discolor. Temperature changes won't bother them. They're easy to clean and their colors are built-in to last the life of the car.

KOPPERS PLASTICS



Find out how Koppers family of fine plastics can help improve your product at less cost to you. For more complete information, contact Koppers Company, Inc., Plastics Division, Dept. 132, Pittsburgh 19, Pennsylvania.

A MOTOR
IS A
SERIES OF
CIRCLES



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including **EPA-SEAL** epoxy insulation for use where conditions are most severe.

W-3

ELLIOTT COMPANY
TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS • EJECTORS • STRAINERS • TUBE CLEANERS

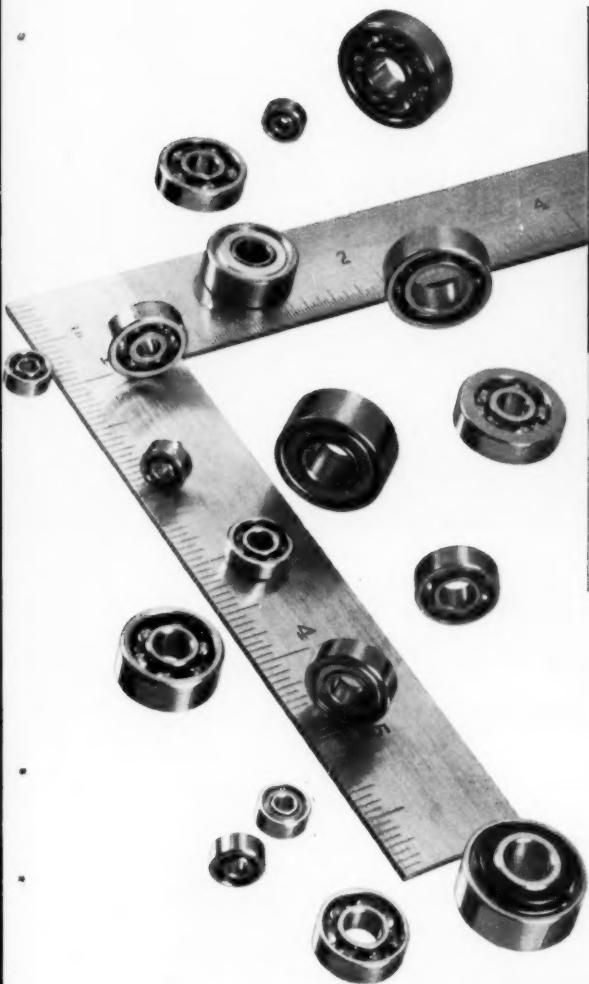
GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

Look to

FAFNIR

for leadership in ball bearings



...Space-saving ball bearings
for compact power tools

Power tool makers pack king-size muscle into hand-size heavy-duty drills! Fafnir Extra-Small Ball Bearings help turn the trick. Developed by Fafnir, these bearings are engineered with deeper, smoother honed races and larger balls—to package more brawn in smaller space. Look to *Fafnir* for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

50 YEARS OF EXPERIENCE
IN THE MANUFACTURE OF
BALL BEARINGS

FAFNIR
BALL BEARINGS



From **FAFNIR...**
dirt-proof ball bearings that
keep harvesting costs down

This giant combine takes a big cut! It's built to cut maintenance, too. Fafnir R-Seal Ball Bearings keep dirt out, grease in, and servicing at a minimum. Developed by Fafnir, the R-Seal is the most effective seal of its kind. Look to *Fafnir* for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

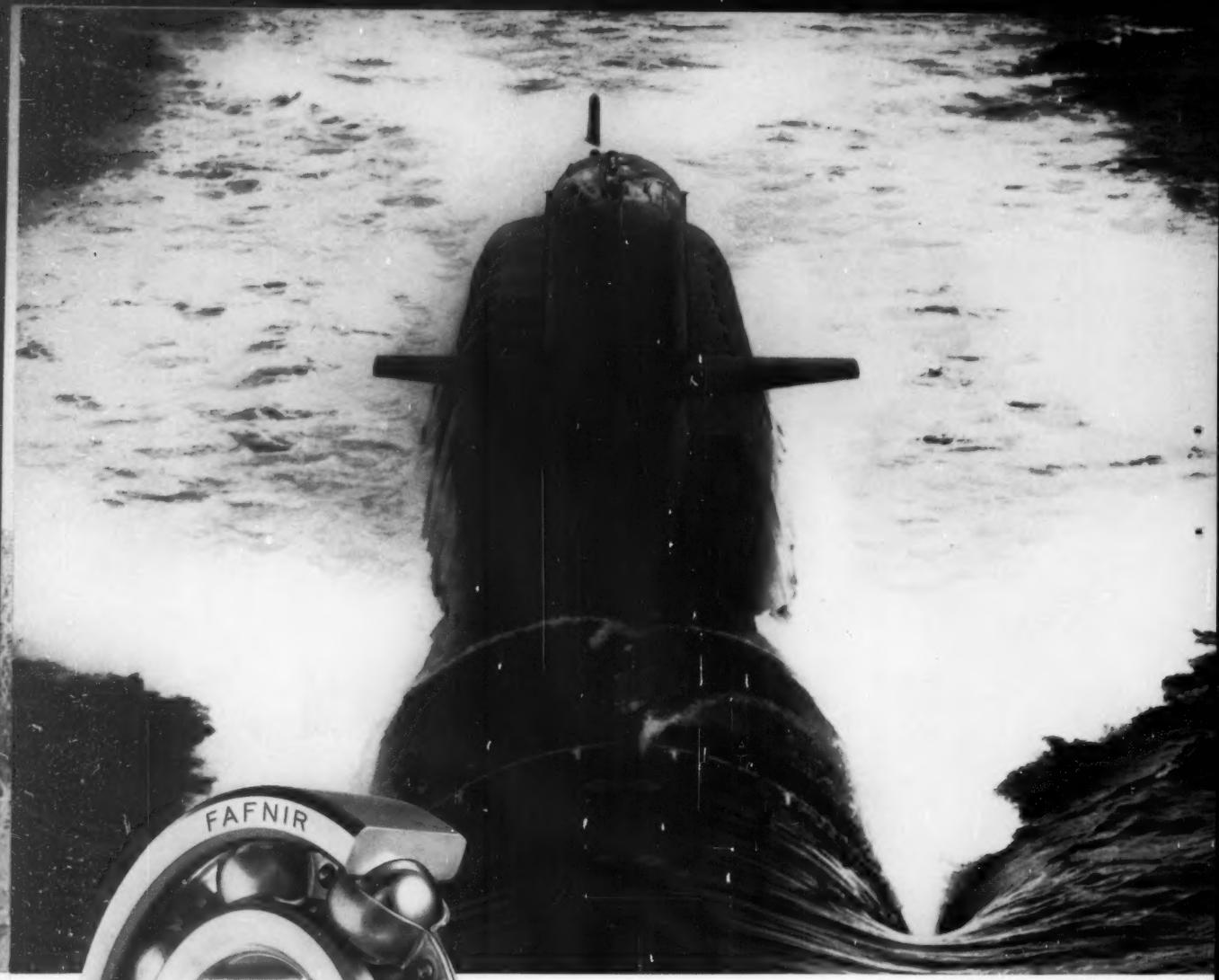
FAFNIR
BALL BEARINGS



From **FAFNIR**...
heat-stabilized ball bearings
for man's first flight into space

A thumb jabs a button... the X-15 drops away from its mother ship... blasts into life... and rockets its pilot to meteoric heights and speeds! "At the controls"... Fafnir Ball Bearings. Born of Fafnir high-temperature metallurgy, these bearings are engineered to take blistering Mach 5+ heats, and more! Look to Fafnir for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS



OFFICIAL U. S. NAVY PHOTO



From **FAFNIR**... super-quiet ball bearings for the new Polaris subs

New nuclear-powered Polaris submarine, the *USS Robert E. Lee*, uses Fafnir Super-Quiet Ball Bearings. These specially honed bearings are the product of 23 years of Fafnir "quiet room" research and advanced finishing techniques. Look to *Fafnir* for leadership in ball bearings. The Fafnir Bearing Company, New Britain, Connecticut.

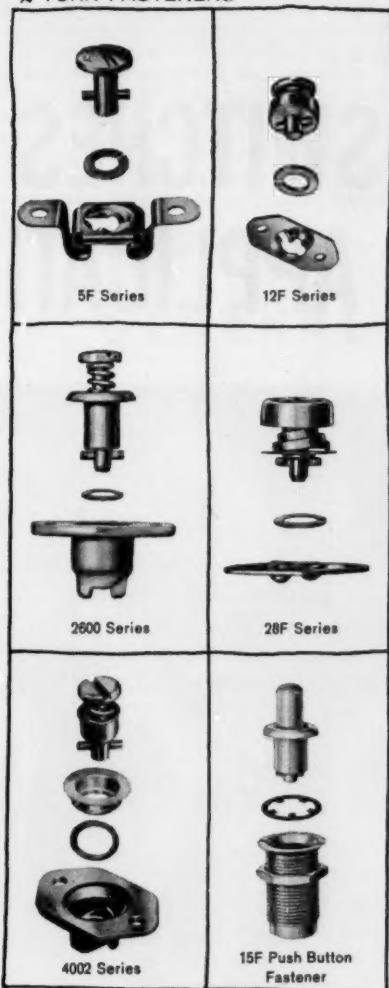
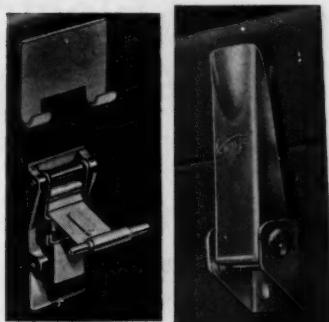


MADE IN U. S. A.
This stamp on a Fafnir Ball Bearing means finest quality and workmanship . . . dependable supply . . . competent engineering help . . . and responsibility in meeting your bearing needs. It's worth bearing in mind.

Circle 258 on Page 19

FAFNIR

BALL BEARINGS

1/4 TURN FASTENERS**UNIVERSAL LATCHES**

30L

51L



37L

46L

CHASSIS LATCHES

21L Latch



35L Latch

HARNESS CLAMPS

7C1 Clamp

FASTEN/ATION

The mechanics of modern fastening have matured to the point where it is now considered a science. We call it FASTEN/ATION.

Your designs are important enough to build, and should be covered and protected . . . but you must be able to remove the covering in a hurry. Here's where Camloc's FASTEN/ATION becomes significant to you. Installation is simple — closure is simple — opening is even simpler, and each of these operations takes only seconds.

The final touch to a good design includes the best method of fastening, the simplest installation and use, and a fastener that complements the product in size and appearance. Since making a decision involves the evaluation of alternatives, here are some of Camloc's more popular fasteners. We know you will want to make a more careful analysis before you specify, we suggest that you write for our complete catalog. Be FASTEN/ATED! Let us FASTEN/EER your next design.

specialists in fasteners for industry

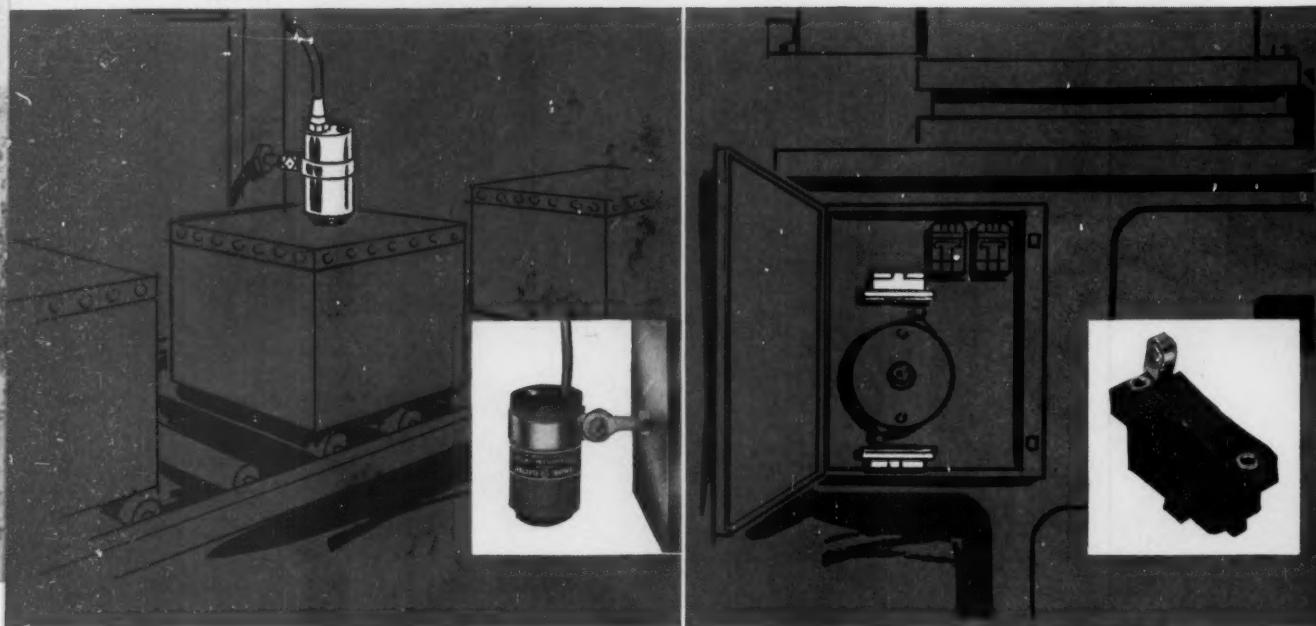


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CAMLOC FASTENER CORPORATION, 37 SPRING VALLEY RD., PARAMUS, N. J.
West Coast Office, 5455 Wilshire Blvd., Los Angeles, California • Southwest Office, 2509 W. Berry St., Fort Worth, Texas

From General Electric . . .

FOUR NEW LIMIT SWITCHES FOR HARD-TO-SOLVE APPLICATIONS



Priced lower than any comparable switch . . .

NEW PROXIMITY LIMIT SWITCH DETECTS MAGNETIC OR NON-MAGNETIC METAL

Now General Electric announces a proximity switch that gives the maximum reliability of an *all-transistorized* circuitry (no vacuum tubes), self-contained in the operating head. The switch senses ferrous material up to one inch, and even non-magnetic metal up to one-half inch. No shielded cable is required. No physical contact is required to actuate this limit switch, so there are no arms, levers, or shafts to wear out. The proximity switch is encapsulated to prevent entry of coolants or contaminants, and will even operate under water. All these features are combined in the lowest priced proximity limit switch available today.

SPECIFICATIONS

Maximum repetitive accuracy: .005 inch

Minimum differential: .01 inch

Operating time: 20 milliseconds

Temperature: Operates in ambients to 150 F

Application: Can be used with magnetic devices or static control

Sensing head rating: Input—30 volts d-c; Output—30 volts d-c, 250 milliamperes

Publication: GEA-7318

Circle 233 on Page 19A

For fast response where space is limited . . .

NEW PRECISION SNAP-ACTION LIMIT SWITCH OFFERS HIGH ACCURACY

General Electric's new precision snap-action limit switch is designed to bridge the gap between the very small and sometimes fragile limit switches, and larger, enclosed limit switches. If space is limited . . . if you don't need the extreme sensitivity of the small switches . . . and if you *do* need heavier-duty operation with good repetitive accuracy and fast response . . . the precision snap-action limit switch is the answer for your application.

The limit switch is available with plunger or roller lever operators. Both types utilize a four-point contact structure (no common connections) in single-pole, double-throw forms, for more flexible circuit applications.

SPECIFICATIONS

Contact arrangement:

SPST—1 NO or 1 NC

SPDT—1 NO—1 NC

Ratings:

AC—up to 40 amps make, 15 amps break; DC—up to 2 amps "make" and break on single-throw forms with .040 gap; Single throw switches are suitable for $\frac{1}{2}$ hp, 115 V or 230 V, a-c. All forms available from 110-600 volts

Publication: GEA-7319

Circle 234 on Page 19A

Proximity and Precision Snap-action Switches Added to General Electric Line

Limit switches are often called the "weak link" in industrial control. But introduction of four new, precision limit switches by General Electric has helped solve this problem. Vane- and magnet-operated limit switches, introduced in 1960, have virtually eliminated mechanical failures on many applications.

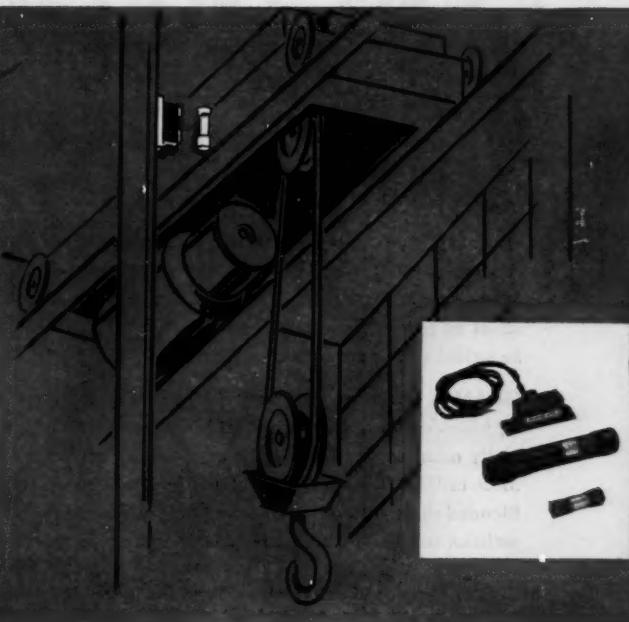
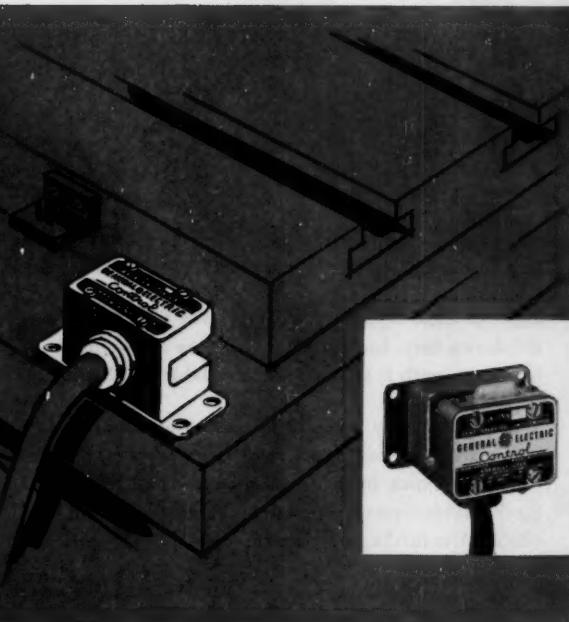
Now G-E announces a new low-priced proximity switch that detects non-magnetic as well as magnetic metal with outstanding reliability. And for high accuracy, fast response requirements where space is limited, General

Electric offers its new open, precision, snap-action limit switch. For more information, call your G-E sales engineer or write Section 811-21, General Electric Co., Schenectady N. Y. for publications listed below.

You Get **MEASURABLE ADVANTAGES**
WITH GENERAL ELECTRIC CONTROL

Progress Is Our Most Important Product

GENERAL ELECTRIC



For leverless operations . . .

NEW VANE-OPERATED LIMIT SWITCH IS ENCAPSULATED FOR LONGER LIFE

The completely encapsulated design of the new vane-operated limit switch seals out liquids, dirt, and metal chips. The switch has no arms, levers, or shafts to fail. The result is extremely long life. For example, with small a-c relays, the expected operating life is 30 to 50 million operations. The switch is actuated by passage of a separate ferrous vane through a slot. There is no physical contact, and the only moving parts are contacts which flex slightly. Price is only slightly higher than conventional limit switches.

SPECIFICATIONS

Response time:	.001 second
Repetitive accuracy:	.0025 inch or less
Contact rating:	0.75 amp "make" at 115 volts a-c 0.2 amp carry and break at 115 volts a-c
Differential:	1/8 inch (NO contact) 1/4 inch (NC contact)
Contact arrangements:	1 NO or 1 NC
Publication:	GEA-6995

Circle 235 on Page 19A

Where operating path is variable . . .

NEW MAGNET-OPERATED SWITCH OPERATES UP TO 4 INCHES FROM MAGNET

General Electric's new magnet-operated limit switch offers the features of the vane-operated switch, plus the ability to detect objects moving in erratic paths. The switch is operated by passage of a permanent magnet near the face of the switch. The larger of two available magnets can be approximately four inches from the switch, and still actuate it. A wide variety of mounting arrangements is possible: Either switch or magnet may be mounted on moving part, or both may be stationary with vane passing between.

SPECIFICATIONS

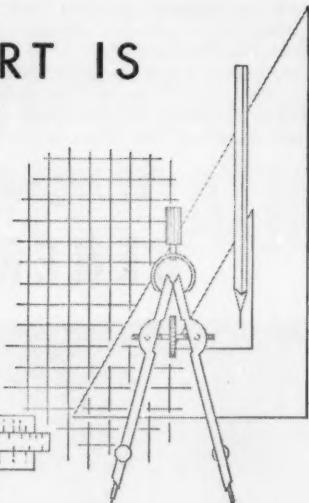
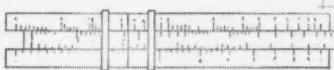
Response time:	.001 second
Repetitive accuracy:	With 1/8 inch dia. magnet—±.003 inch With 1 1/2 inch dia. magnet—±.007 inch
Contact rating:	0.75 amp "make" at 115 volts a-c 0.2 amp carry and break at 115 volts a-c
Contact arrangement:	1 NO
Publication:	GEA-7305

Circle 236 on Page 19A

TO INSURE SUCCESSFUL PERFORMANCE

EVERY **GRAMIX®** PART IS
(PRODUCTS OF POWDER METALLURGY)

APPLICATION ENGINEERED



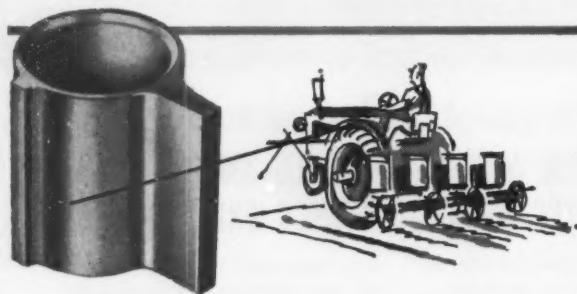
One of the most important factors to consider when purchasing powder metal parts is that of successful part performance; for a part to successfully perform its job, all of its physical and metallurgical characteristics must be suited to the application.

GRAMIX Products of Powder Metallurgy are always *Application Engineered*, which means product is specially matched to each specific application. From an almost unlimited variety of metal mixtures, one alloy is blended that contains the required properties and characteristics of the finished part; *all* aspects of part design

and conditions under which it must operate are taken into account. Only then is the GRAMIX part produced.

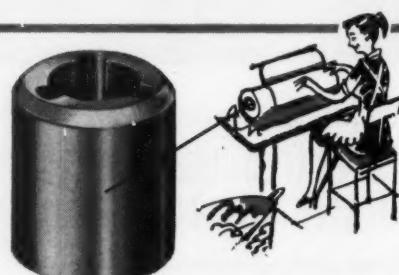
Eight of these *Application Engineered* GRAMIX parts are shown here. Each precisely suits the requirements of its job . . . each is the best part available for the job.

When you specify a GRAMIX part, you can always be sure that it has been *Application Engineered* for successful performance, long life and complete reliability. For more information on *Application Engineered* GRAMIX parts, write for Engineering Handbook G-55.



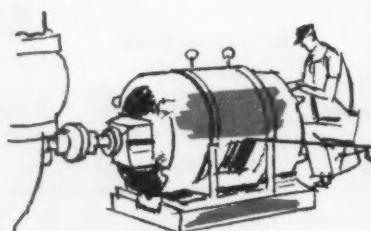
CORN SEEDER

GRAMIX was the material specified for this corn seeder part because the surface finish obtainable with the alloy used reduced the tendency of material to stick to the surface.



CONNECTING COUPLING

The connecting coupling employed in a small home ironer is formed from a special GRAMIX hardened steel alloy; it offers low wear and shock resistance.



CONTAINER COVER END CAP

Great savings were realized when retainer caps for certain types of electric motors were made of GRAMIX.

This process made it simple and economical to mold the multiple holes to precise tolerances without extra operations.



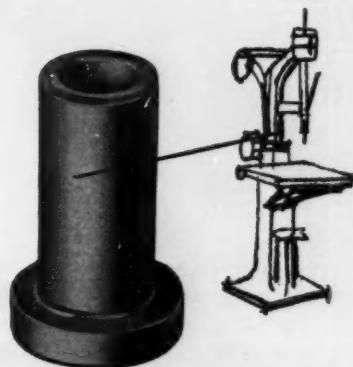
HELICOPTER THRUST WASHER

The outstanding features of the GRAMIX alloy specified for this thrust washer are a dependable and consistent friction and wear pattern as well as a fine surface finish.



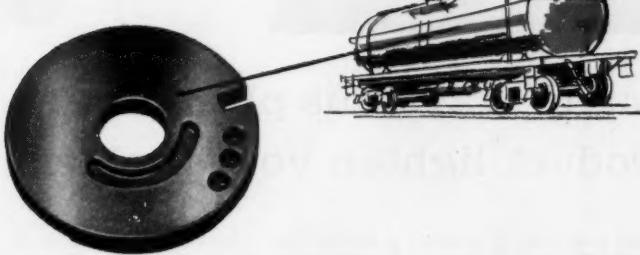
TAPE RECORDER SPINDLE

One of the important requisites in a tape recorder is a low noise level. United States Graphite Company engineers developed a special alloy to meet these requirements in the GRAMIX spindle.



GUIDE BEARING

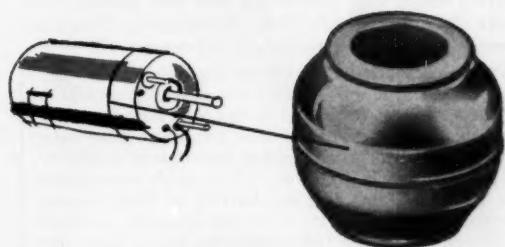
Built-in lubrication and low friction to reduce heat are important features of the GRAMIX alloy chosen for this guide bearing.



LIQUID PUMP END PLATE

This end plate is typical of many parts employed in liquid pumps of many types.

It is made from a wear resistant bronze alloy that was developed for pump applications.



FRACTIONAL H.P. MOTOR

The GRAMIX bearing for this Fractional h.p. motor was developed from a special low noise level alloy.

Its self-lubricating properties were also an important consideration in specifying GRAMIX.



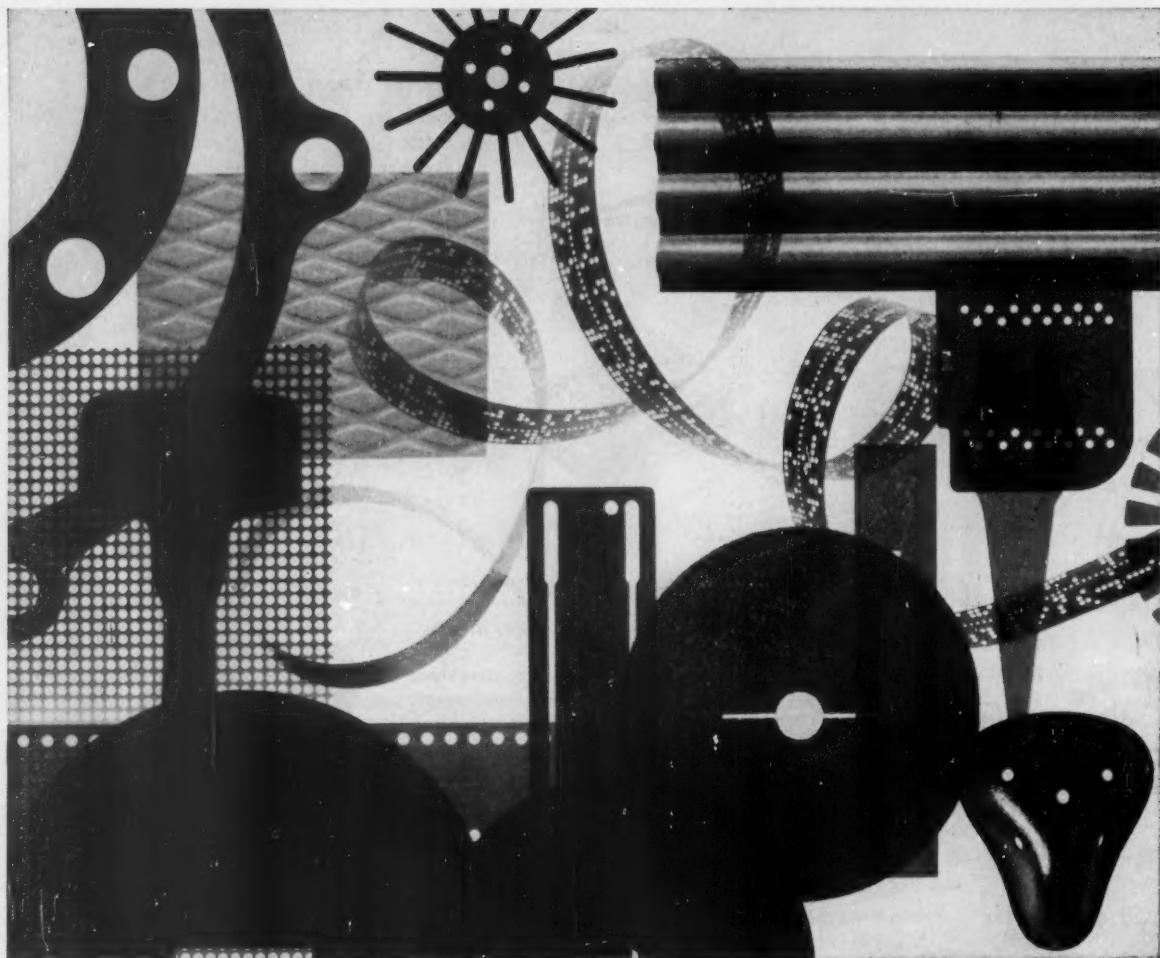
X-296-2

THE UNITED STATES GRAPHITE COMPANY



DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAFITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



Consider the many ways this plastic can toughen your product, lighten your problem

National Vulcanized Fibre is one of the most do-more, save-more, get-around materials ever produced. Thousands of jobs well done have established its reputation. Yet there are still other cost-cutting applications to be explored, many that no other plastic can handle.

What is Vulcanized Fibre? A tough, dense cellulosic plastic. As track insulation, thousands of tons of Vulcanized Fibre are now absorbing the steady beating of trains passing over. Has superior arc resistance; high dielectric strength; is class "A" electrical insulation. Low thermal conductivity, high resiliency, great shock and abrasive resistance. Shrugs off oil, gasoline, most solvents. A most un-ordinary plastic. Weighing but half as much as aluminum, Vulcanized Fibre is one of the strongest of materials for its weight.

You can machine, punch, form, deep-draw; combine with rubber, copper, laminated plastic, and other materials. Takes polish, paint, embossing. Consider design and shape . . . you'll find Vulcanized Fibre as motor slot insulation or in intricate forms such as gear assemblies.

There are 16 standard and many special grades, among them "Pyronil", which is fire-resistant. You may well find precisely the properties needed to make your

product a better buy. There's a free sample kit waiting for you at a nearby NVF sales office. Check Sweet's Product Design File 2b/Na for the one nearest you. Or write directly to Dept. G-4, Wilmington, Delaware.

116 Choices: One Source This is the latest count of the different plastics and grades NVF can offer in your search for the *one best material*. Add to this total *the one* special grade that can be developed from scratch to meet your particular need. This full range of materials is backed by complete engineering services . . . from application assistance up to and including the delivery of 100% usable, precision-fabricated parts . . . in any quantity, on time!

Call the NVF Sales Office near you. It's a direct line to single-source help on your current materials problem.



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CUSTOM GEARS and GEAR BOXES
permit *complete freedom* in design. You
specify and get gearing made precisely
to your exact requirements.



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tom gears are made in all types to 72"
diameter cut teeth, 39" shaved teeth, 25"
ground teeth.

better still... Send us your prints for quotation



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Custom Gear Makers Since 1907 GEARS, good gears only

How to design sales power

HERE'S WHY ACME IRON WORKS

THE ENGINEER SAYS...

"It's easy to design equipment using International engines and transmissions. Accessory mountings are no problem, and International's technical experts are eager to help with special requirements."

—Marvin Quay, Chief Engineer,
Acme Iron Works, San Antonio, Texas



Chief Engineer Quay is an enthusiastic International booster, though not the first to specify IH power. For most of the company's 35 years in business, International engines have been standard equipment.

Vice President and General Manager Bryant Ingram with new 10-ton pneumatic roller, powered by International UC-221 engine. The roller has five speeds forward and reverse, mounts five rear tires on oscillating axles.

Acme management is pleased with Engineer Quay's power choice. Mr. Ingram, General Manager of Acme, says, "We have installed thousands of International engines in our products and never had a complaint. They produce the right power, and have a long service life. Records show that they need fewer repairs. No matter where we may ship a roller, engine parts can be supplied quickly by International outlets in every part of the country."

An increasing number of designers and manufacturers are solving heavy-job power problems with International engines. When you specify IH power you simplify engine installation, service and repair.

Should your design encounter problems, International engineers will help you work out a practical solution. Check your own requirements against the solid, sensible facts stated by engineers who prefer IH power. When all points are considered, the choice is International.

There are 35 models in the International line from 16.8 to 385 max. hp, stripped engines to complete power units. The wide range of sizes includes diesel, gasoline, LP gas and natural gas models, with features for extreme adaptability in every size. For further information call or write to International Harvester Co., Engine Sales Dept., Melrose Park, Ill.

into your products...

SPECIES INTERNATIONAL POWER

THE SALESMAN SAYS...

"People like International engines, and most of our prospects are already familiar with the extensive IH parts and service organization."

—E. M. Anderson, Vice President, Sales,
Acme Iron Works, San Antonio, Texas



THE CUSTOMER SAYS...

"Our operation demands top performance and 100% availability. Experience with eight IH-powered Ingram Rollers has shown them to be most reliable. They give us steady operation, year after year, with only an annual inspection."

—Travis Jenkins, General Manager and V. P.
C. H. Allison, Inc., San Antonio, Texas

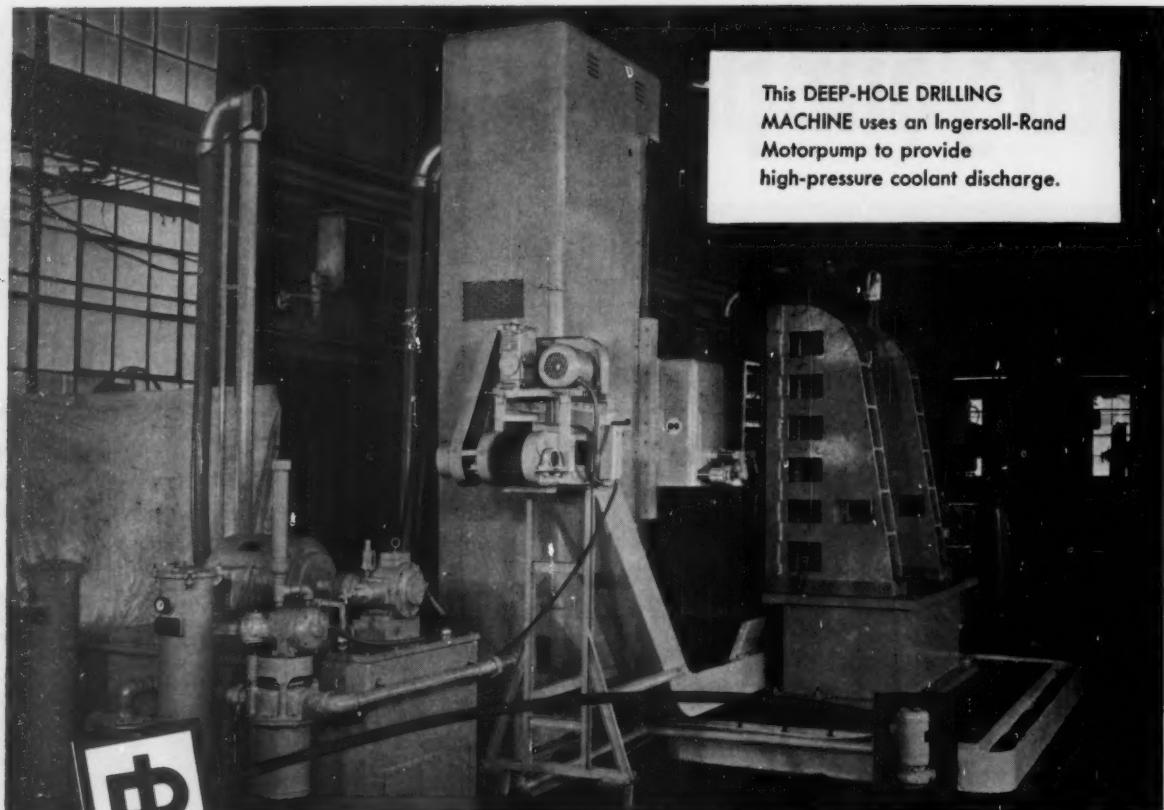


Acme salesmen sell their equipment by going over the product's features, point by point. When they come to the engine, they seldom have to say more than, "It's an International!" This, more than anything else, tells the prospect that the machine is quick-starting, economical to operate, and easy to service. It's the part you don't have to sell, because prospects are already familiar with International economy and dependability, as well as the world-wide parts and service organization. This pre-sold power package adds another plus feature to your sales story. Thousands of users report the outstanding performance of International engines. From crop sprayers in Florida to construc-

tion equipment in Alaska, the word is that IH-powered machines start faster, work better, last longer. Investigate International soon, and find out how easy it is to design Sales Power into your products.

INTERNATIONAL[®]
II ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE



solves pumping problems for equipment designers

Ingersoll-Rand today offers machine builders and equipment designers the widest possible choice of pump models. Ingersoll-Rand can solve your liquid-movement problems and meet your specifications exactly or we will design and build the pump you need if existing models can't be fitted to your requirements!

Check with Ingersoll-Rand today. The pump specialist at your nearby I-R branch office is always ready to help, or write for catalog data.

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Immersion and sidewall mounted Motorpumps
 1/4 through 20 hp delivery to 1000 gpm
 heads to 170 ft

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Motorpumps



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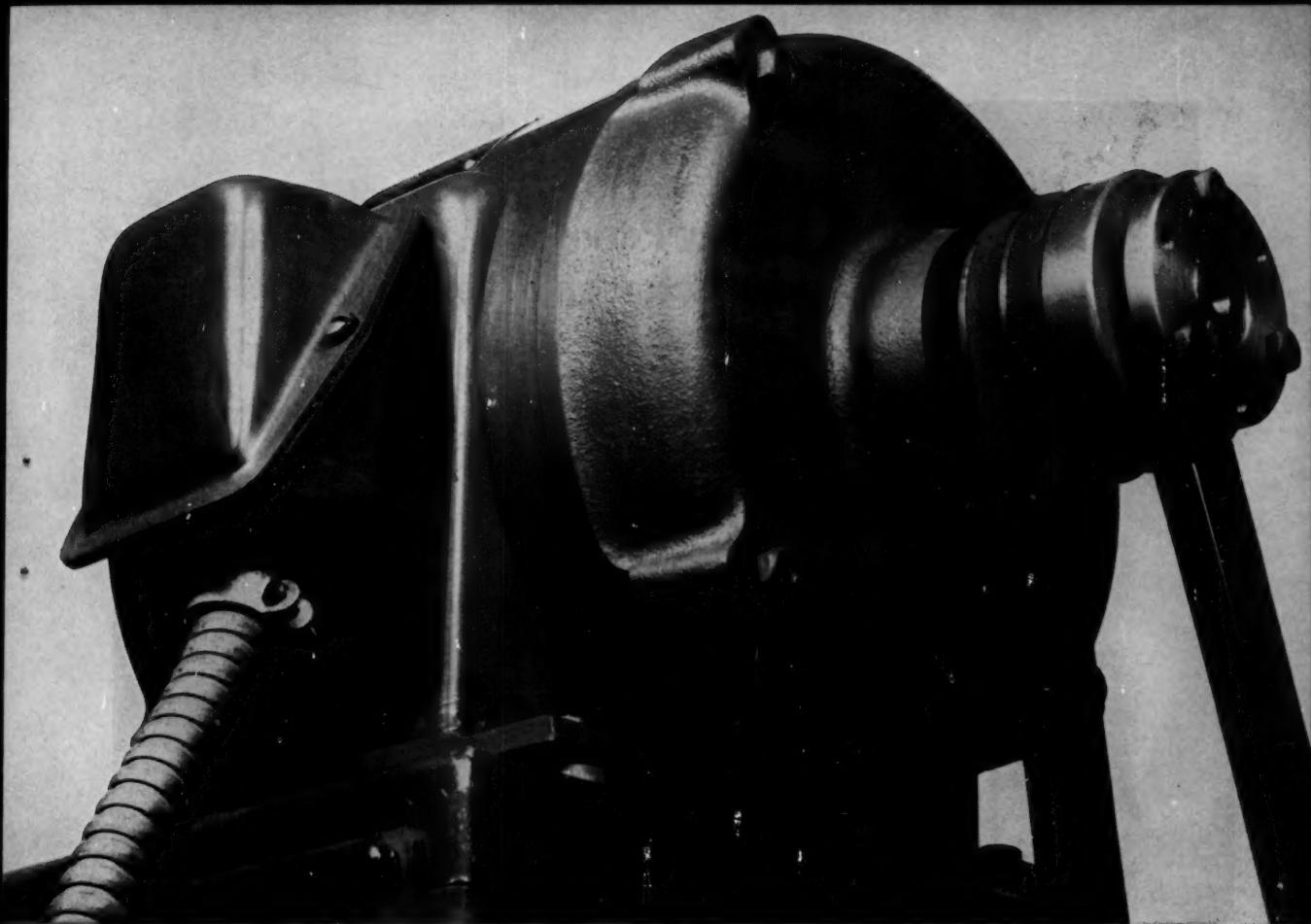


Self-Priming Motorpumps



Horizontally-Split Pumps

145A9

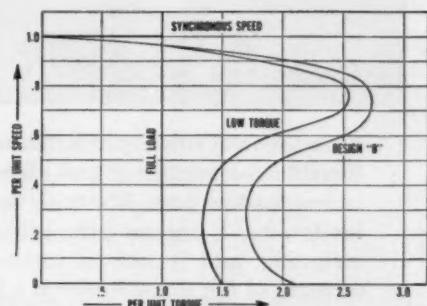


Special Century Motors Control Belt Screech

These Century polyphase motors are designed for *low* starting torque. They are mechanically interchangeable, rating for rating, with Standard Design B motors. But, as shown in the speed-torque curve, they are internally designed for static torque only 50% more than full load torque. There are some applications where this low torque at standstill is an advantage.

Belted drives have always been the cause of some noise—the same disturbing sound made by tires skidding on pavement. Flat belts had a characteristic sound at all times, varying from a "singing" sound to a real "screech." In recent years, quiet belted drives have been possible with the universally used V-belts. A continuing problem has been to start the driven machine without a few seconds of screech. When the typical motor (Design B or Design C) is energized, it develops so much torque that even properly applied V-belts are apt to screech as they bite into the sheaves. In many locations this noise is objectionable. And the high starting torques impose unnecessary strains on the driven machine.

For driven machinery (such as blowers) having a low starting torque requirement, we have found that the objectionable noise can be eliminated by this special design motor. This proved to be a simple solution to a vexing problem for several of our customers. For help on your motor problems, call your Century Sales Office.



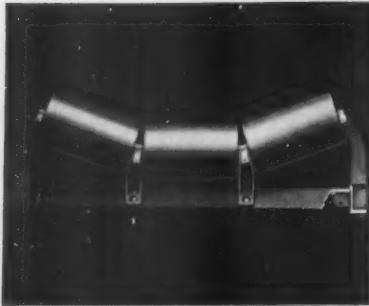
Comparison of typical rating — NEMA DESIGN "B" and SPECIAL LOW TORQUE DESIGN

CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri Offices and Stock Points in Principal Cities

Circle 242 on Page 19

Century
60-1



Jeffrey Permaseal® Idlers selected for Ko-Cal Roughloader



Koehring Company of California builds this Ko-Cal Roughloader to quickly and efficiently handle the largest loading jobs. It's being used extensively for low-bank borrow pits, highway cuts, mine stripping, and in use by top-soil dealers. Top capacity of the Roughloader is 1 yard per second. It moves sticky or rocky materials that tend to bridge and so cannot be efficiently handled by a feeder-type loader.

The practically maintenance-free service of these portable units depends in large part on the ability of Jeffrey Permaseal Idlers to help carry the load. Permaseal Idlers' unique double-seal design proves ideal for installations like this—where

dust and dirt could create a real problem. On job after job, Permaseal Idler design protects bearings as they've never been protected before—stretches greasing intervals to years.

Complete information about how you slash direct and indirect costs with Jeffrey Permaseal Idlers is available in Catalog 925A. For your copy, write The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.



JEFFREY

If it's conveyed, processed or mined, it's a job for Jeffrey.



The Bellows Air Motor® Makes Pneumatic Circuits Easier to Design • Easier to Build

The Bellows Air Motor makes designing for air operation a lot easier and less costly. Its built-in directional valve, built-in speed controls, and its single air connection (which can be flexible hose) is true space-saving design—makes it fit perfectly in cramped quarters or on moving machine elements. And from the standpoint of final design, the Bellows Air Motor offers faster action, more positive control, and minimum maintenance.

The Bellows Air Motor is available in various mounting styles, in five bore sizes (1 $\frac{1}{4}$ ", 1 $\frac{3}{4}$ ", 2 $\frac{1}{2}$ ", 3 $\frac{5}{8}$ " and 4 $\frac{1}{2}$ "), and in any stroke length. Optional built-in valves include 8-12v low voltage control, 115v JIC electric control, manual or pneumatic controls, thus giving the design engineer the widest latitude in control systems.

Full data on Bellows Air Motors is in Bulletin BM-25, free on request. Write Dept. MD-461, Bellows-Valvair, Akron 9, Ohio.

Bellows-Valvair
AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

996-C



Find out today how
REVERE TUBE-IN-STRIP
 can help you save money...
 improve product quality

Shown on these pages are three of the many, many ways Revere Tube-In-Strip is used. Such money-saving performances are made possible by the fact that Revere Tube-In-Strip is a solid piece of flat sheet or strip metal with built-in passages that may be inflated, by pressure, into tubes. Thus the tubes become an integral part of the metal.

Expanding in the open, the tubes are round; by expanding into dies, the tubes can be rectangular, fluted, half-round, hexagonal, etc.

Revere Tube-In-Strip saves on first cost, and in fabrication. New and improved designs are made possible. The web between the tubes conducts heat faster. The vastly increased structural strength means you can use lighter gauges, saving in weight and price.

Revere Tube-In-Strip is available in Copper, Copper-base alloys, and Aluminum alloys. The Revere Technical Advisory Service and the Research and Development Department will gladly collaborate with you in taking full advantage of this marvelous new material.



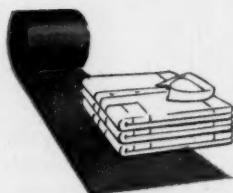
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COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: 230 Park Avenue, New York 17, N. Y.
 Sales Offices in Principal Cities. Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford and Plymouth, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb.

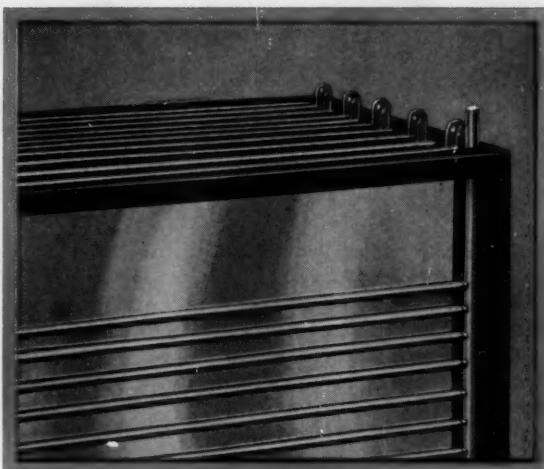
Distributors Everywhere

*SAVES \$1,485.37 in 4-month period as Heat Reclaimer . . .

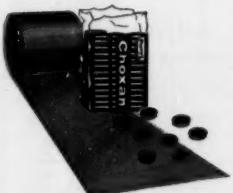


This heat reclaimer, made by KILLEBREW ENGINEERING CORPORATION, St. Louis, Mo., consists of a battery of 30 panels, with 3 panels of Revere Copper Tube-In-Strip, riveted together, measuring 48" x 82" overall. Water used for washing is heated as it flows through the tubes. The unit, installed in the 78-year-old industrial laundry operated by CHAS.

TODD OVERALL CLEANING CO., saved, in a 4-month period, \$1,485.37, with the laundry operating on a one-shift basis and at the desired water temperature. During that time, 200,000 more pounds of laundry were washed than in the previous 4 months at a \$100.00 saving in steam cost. Prior to that time, due to a limit on the amount of steam that could be purchased, the laundry had to use a lower water temperature and operate on a two-shift basis.

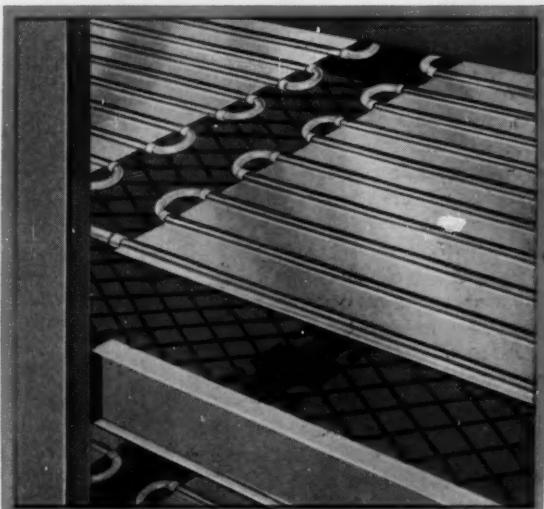


*SAVES UP TO 30% for biscuit maker, improves product quality . . .

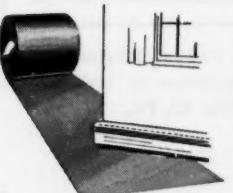


At the BURRY BISCUIT CORPORATION, Elizabeth, N. J. about 7,000,000 lbs. of product is turned out in 20 days, a large portion of which is chocolate coated and processed through the Reflectotherm system of reflective radiant cooling. This unit consists of a 108'-long, fully enclosed tunnel. On top and bottom of the tunnel are nine 8' sections of Revere Copper Tube-

In-Strip through which is pumped a cooling medium at 8 to 12 degrees F. This results in the chocolate, through radiation, being set properly within 4½ to 5 minutes. Also included in this installation is a Reflectotherm drying unit, made of Revere Tube-In-Strip, by which 250 cubic feet of super-dry air per minute, at a temperature below zero, is forced between the plates. Burry Biscuit, one of the country's leading independent bakers, reports a tremendous improvement in product quality with an increase in production running as high as 30%.

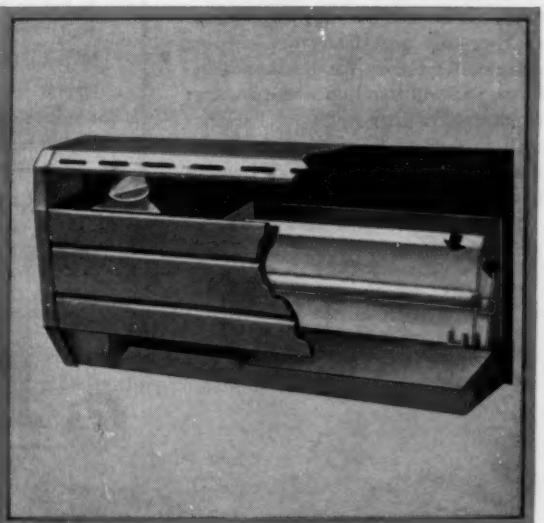


*SAVES MANUFACTURING COSTS increases efficiency of Electric Baseboard Heaters . . .



MEIER ELECTRIC, Indianapolis, Indiana, chose Revere Aluminum Tube-In-Strip for their line of electric baseboard heaters after numerous materials and designs were tested by their Engineering Department. The rigid design objectives were: (1)—Encase Heaters in a non-corrosive material, (2)—Use Tandem 500 plug-in case for 500, 750 and 1000 watt units while maintaining lower case temperatures

at all wattages, thus eliminating duplication of dealers' stocks, (3)—Include inbuilt thermostats, junction boxes and thermal cutout in the unit to simplify construction, save space and cut manufacturing costs, (4)—Retain the quietness, lack of wall streaking and safe, low case temperatures originally available only in the 500 watt Tandem. All of these objectives were ultimately accomplished by using Revere Aluminum Tube-In-Strip to encase their heating element (see arrows).



Important differences in fire-resistant fluids

Unlike petroleum oils, fire-resistant fluids have markedly different chemical properties which should be carefully considered before making a final selection.

To simplify this selection, we show here some of the variables—and limitations—of the three major fire-resistant types. Houghton is uniquely qualified for this unbiased analysis since we favor no one type over another. We make them all—and a full range of hydraulic packings as well.

1. Water-Glycol Fluids

These fluids contain water, glycol and a thickener. They provide the highest degree of fire protection. They are also compatible with the widest range of packing materials including those commonly used with petroleum oils. They should only be used, however, in systems operating at reservoir temperatures below 150°F.

Houghton's Houghto-Safe 200 and 600 Series are of this type and enjoy top acceptance and use by the armed services, as well as general industry. This wide-spread usage is due to important additives that provide *extra* anti-wear, rust inhibiting, anti-foam and metal deactivator properties to improve performance and increase pump life.

2. Phosphate-Ester Fluids

Fluids of this type are composed of straight phosphate esters and may contain small amounts of additives. These fluids can be used over the widest range of hydraulic pressures; they provide maximum lubricity for heavy bearing loads, and will stand up where ambient temperatures exceed 150°F. Packings used with these fluids must be Butyl, Butyl-Fabric or Polysulphide-impregnated Leather.

Houghton's Houghto-Safe 1000 Series are phosphate-ester fluids specially se-

lected and compounded with additives to improve wear and rust resistance and add other proven operating benefits. Here again, Houghto-Safe 1000 Series has earned acceptance and is used on many military and space projects, as well as many of industry's toughest applications.

3. Emulsion Fluids

These fluids are either emulsions of water-in-oil (non-ionic) or oil-in-water (anionic). The following statements pertain to the water-in-oil type which are most widely used in industrial hydraulic systems.

Since these fluids are made of water and petroleum, they are compatible with standard Buna N rubber packings. They are also the lowest cost of all fire-resistant fluids. Their fire resistance is also the lowest of all three types; they should be used only in areas requiring a moderately safe fluid. The operating pressures of these fluids is generally limited to under 1000 psi.

Houghto-Safe 5000 Series designates Houghton's emulsion type fluid. It is a water-in-oil (non-ionic) fluid not affected by water hardness. Special additives are used to provide stability of the emulsion and to increase lubricity.

COMPARISON OF HYDRAULIC FLUIDS

Fluid Type	Viscosity Temperature Characteristics	Fire Resistance	Lubricity	Max. Fluid Temp. °F.	Relative Cost
Emulsion Fluids	Fair	Fair	Fair	See Note	1
Water-Glycol Fluids	Very Good	Excellent	Good	See Note	2
Phosphate-Ester Fluids	Poor	Good	Very Good	See Note	3

NOTE:—The Joint Industry Conference (JIC) Hydraulic Standards recommends the following where systems are operated continuously.

1. For water base fire-resistant fluids, the temperature of the fluid should be controlled so as not to exceed 120°F. at the pump inlet.
2. For other fluids, including petroleum oil, the temperature of the fluid should be controlled so as not to exceed 130°F. at the pump inlet.

For unusual system conditions where it is impossible to adhere to these reservoir temperature levels, the Houghton representative should be consulted.

For detailed information booklet describing all types of fire-resistant fluids, or help in selection, call your Houghton representative or write: E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

Houghton
INDUSTRY'S PARTNER IN PRODUCTION



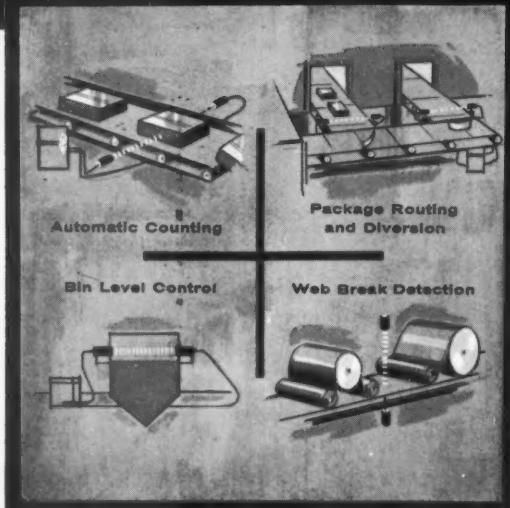
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**...to match the high performance standards of the
nation's top-quality electrical control equipment**

Soon you will see this new trademark on Clark control devices and systems. Behind this symbol are the precise engineering and exacting production methods which make possible the high standards of quality for which Clark is famed. Behind it are men with the know-how to create the longest lived, sturdiest, most efficient electrical controls. Behind it are answers to your needs for everything from standard equipment such as motor starters, relays and push buttons to complete engineered systems.

For help in solving your control problems, contact your local Clark distributor or district sales office, or write direct. *The Clark Controller Company* • Main Plant: Cleveland 10, O.—Western Plant: Los Angeles 58, California—In Canada: Canadian Controllers, Limited, Toronto, Ont.

a new
dimension
in automated
controls



SONAC ULTRASONIC,

NON-CONTACT SENSING AND SWITCHING SYSTEM

Before Sonac, sensing and switching control systems which involved breaking a beam of energy were limited by vibration, dust, smoke, steam, air contamination and too much or too little light. Sonac's ultrasonic energy "beam" is completely free of these limitations. The acoustic lens on Sonac sensors can actually be painted without affecting performance. Utilizing high frequency sound also means there are no lamps to burn out. Savings in replacement parts and maintenance time often means Sonac pays for itself. Sonac is completely transistorized, providing you with a rugged, dependable electronic circuit.

These are just a few of Sonac's many uses. Optional equipment includes reflectors for precision beam and positioning control, and coupler assemblies for use with flexible tubing for remote sensor locations. This descriptive booklet will be sent to you on request.



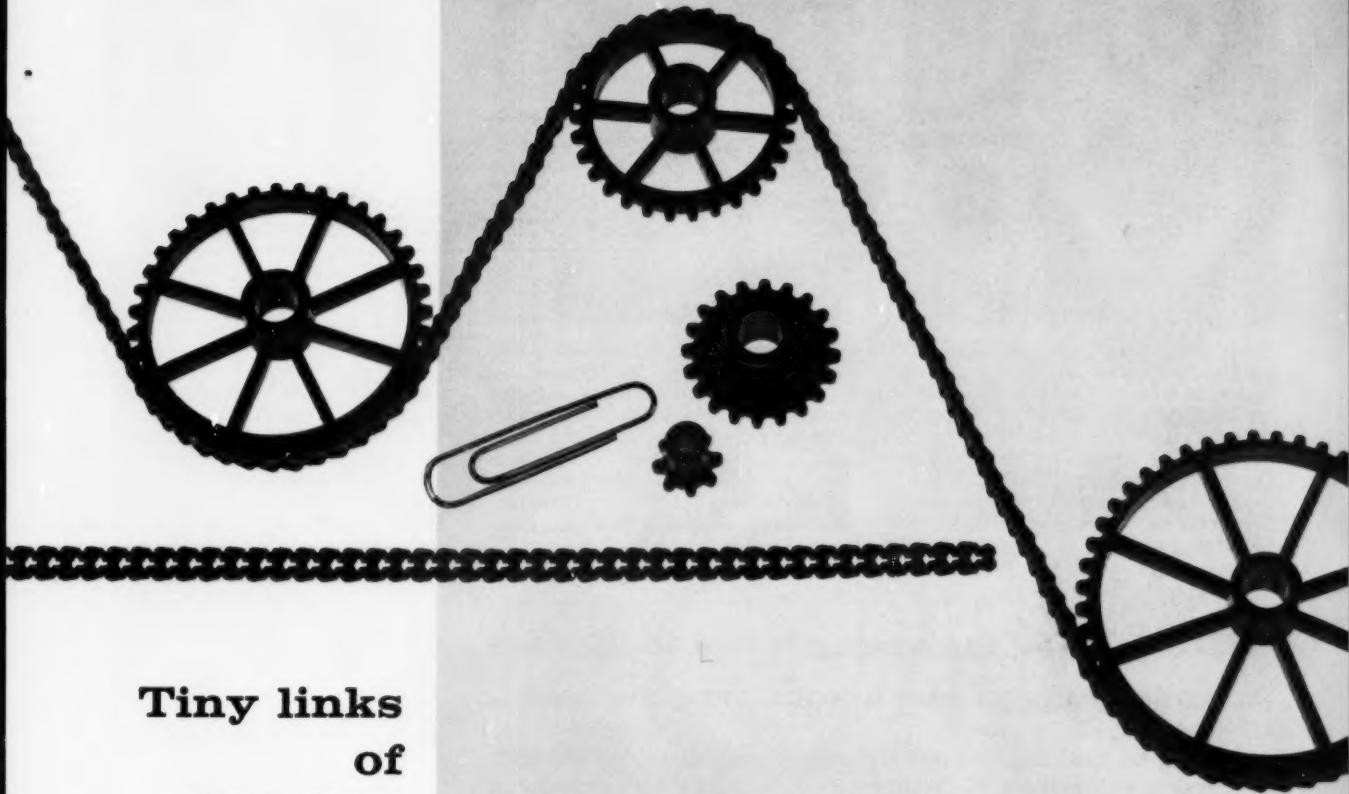
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WEST DES MOINES • IOWA

working with

Du Pont

Delrin

one of Du Pont's versatile
engineering materials



**Tiny links
of
DELRIN®
make a remarkable miniature chain**

These miniature chains and sprockets are significant examples of the way Du Pont DELRIN acetal resin provides superior performance in application areas once reserved for metals. The chain of snap-fit links is made possible by the strength, stiffness and resilience of DELRIN. The need for a master link is, therefore, eliminated, making the chain adjustable in $\frac{1}{8}$ inch increments. The chain weighs only 1 oz. per 15 ft.—one-fifth the weight of similar steel chain. It is factory-tested; momentary tension load at 7 lbs.; and running loads to 2 lbs. Manufacturer's service-life tests show a work rate transfer of 0.06 HP for 10 hours . . . 50 foot-tons of work per inch of chain. The chain is solvent-resistant, pre-lubricated, non-magnetic and non-

conductive. These drive components were designed to fill a need in miniature mechanics and instrumentation in a wide variety of high-speed, low-inertia mechanisms.

The manufacturer, Bohannon Industries of Colorado Springs, Col., reports that of the many materials tested, only DELRIN was adaptable to the intricate technology involved in the development of these miniature drive components.

The unique combination of properties offered by DELRIN solve a variety of design problems in areas as diverse as automobile handles and electronic switches. On the reverse side, you will find additional examples of product improvements made possible by this versatile material.

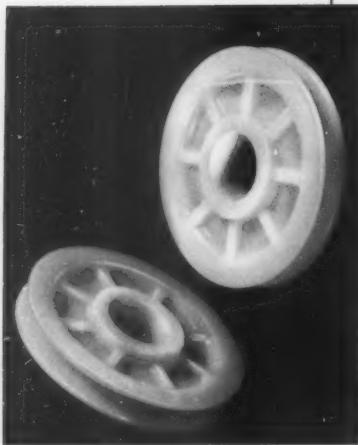
DU PONT

REG. U. S. PAT. OFF.

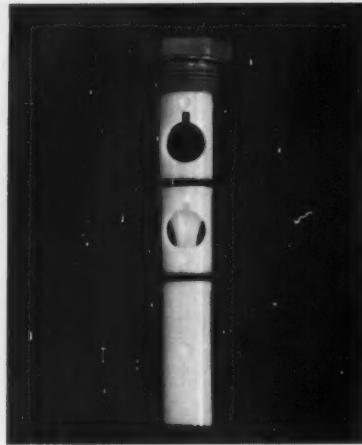
BETTER THINGS FOR BETTER LIVING
THROUGH CHEMISTRY

working with
DuPont Delrin

*one of Du Pont's versatile
engineering materials*



Long-wearing parking-brake cable pulleys of DELRIN® are being used by a leading car manufacturer. The full-radius groove in DELRIN provides natural mating, maximum contact area with the cable . . . eliminates the cable pinching caused by split-type steel pulleys. The new pulleys molded of DELRIN have been tested under severe long-term conditions of high load and temperatures.



Jet injector unit for shallow-well system is molded in three parts of DELRIN and joined by two "one-direction" snap-fits, giving permanent assembly. The new unit outwears bronze by a factor of 2 under sand abrasion . . . molded threads utilize high shear strength of DELRIN acetal resin. (Molded by American Molding Company, San Leandro, for Jacuzzi Bros., Inc., Richmond, California.)



Thumbwheel of this unique multi-deck rotary switch is molded of tough, abrasion-resistant Du Pont DELRIN. A single $\frac{1}{4}$ inch thumbwheel of DELRIN provides the mechanical and electrical insulating properties needed to handle a combination of rotary switches. (Molded by Par-A-Mount Tool & Mfg. Co., Inc., Chesterton, Indiana, for Chicago Dynamic Industries, Precision Products Division, Chicago, Ill.)

DELRIN® has the strength and toughness to meet rugged mechanical requirements

When a part must function reliably under rugged usage, the strength, stiffness and toughness of DELRIN acetal resin may well provide an economical solution. Parts molded of DELRIN retain a high degree of their mechanical properties under numerous conditions, including broad temperature ranges (-40°F. to 250°F.), humidity, solvents and stress.

Already, many hundreds of designs taking advantage of the unique properties of DELRIN, and of the cost savings made possible by rapid injection molding, have been put into commercial production. Why not investigate further with a view to your own products and problems? Mail the coupon below for more information.

POLYCHEMICALS DEPARTMENT



BETTER THINGS FOR BETTER LIVING
THROUGH CHEMISTRY

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Room 2507D Nemours Building, Wilmington 98, Delaware
I am interested in evaluating DELRIN® for the following use:

A
B

Name _____

Company _____ Position _____

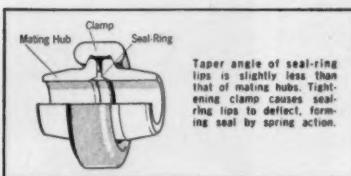
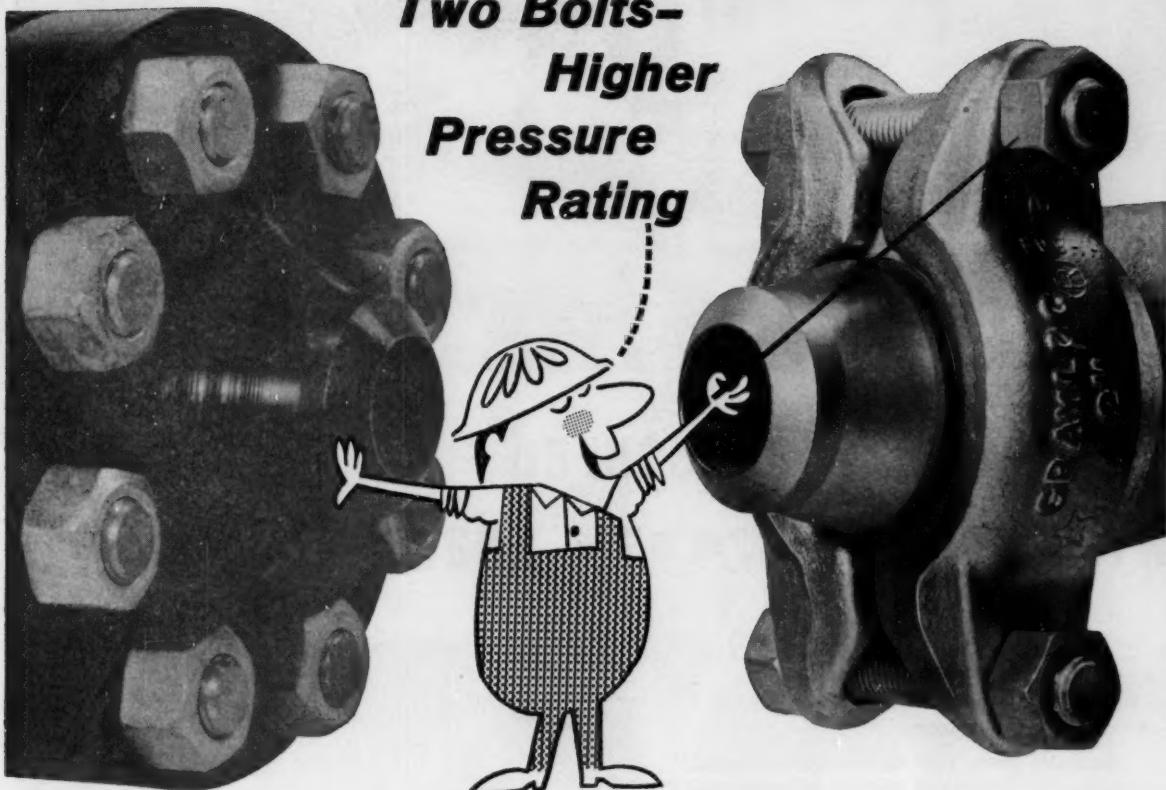
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Two Bolts-
Higher
Pressure
Rating**



GRAYLOC® Pipe Connections can be assembled in less than 1/3 the time required for a comparable flanged assembly — yet GRAYLOC Connections provide as much as twice the maximum pressure rating.

An all steel assembly, GRAYLOC incorporates a pressure aided seal that can be quickly and easily disconnected — the seal ring is completely re-usable. GRAYLOC connections are smaller in size and lighter in weight than any other comparably rated connection.

GRAYLOC Connections are manufactured in standard stock sizes from 1" to 30", with special sizes available on request. Highly corrosion resistant metals are available on short notice.

GRAYLOC Pipe Connections can save you assembly and maintenance time, space and money. Write today for specific engineering information and your copy of the new GRAYLOC catalog.

GRAYLOC SALES DIVISION

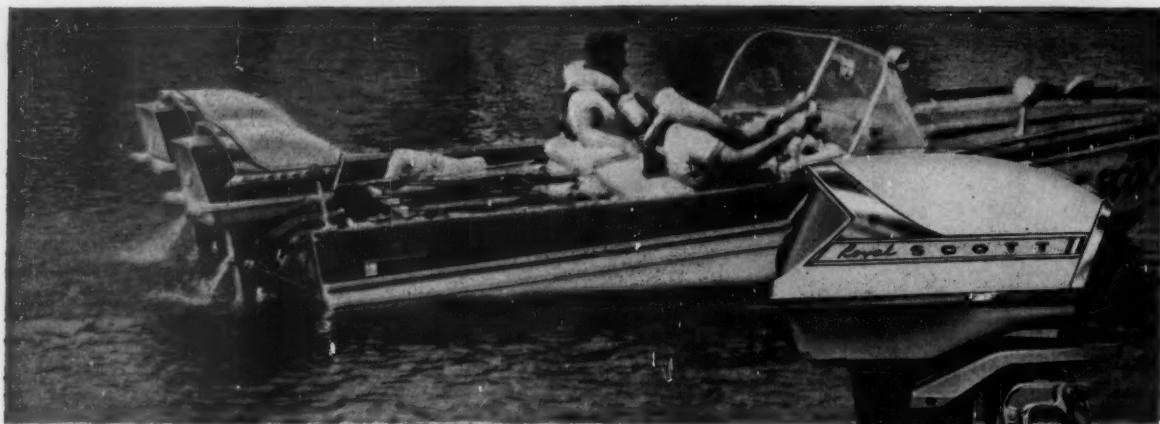
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SCOTT OUTBOARDS "Race-Horse Spirit . . . Work-Horse Power"



Performance assured with **VICTOR** sealing

Scott motor owners know the satisfaction of superior outboard power—rocket getaway . . . smooth idling . . . sustained high-speed cruising—with fuel-saving economy!

It was Scott power that set the 1960 outboard endurance run down and up the Mississippi—4153 miles—in 165 hrs., 15 min. (Photo above.)

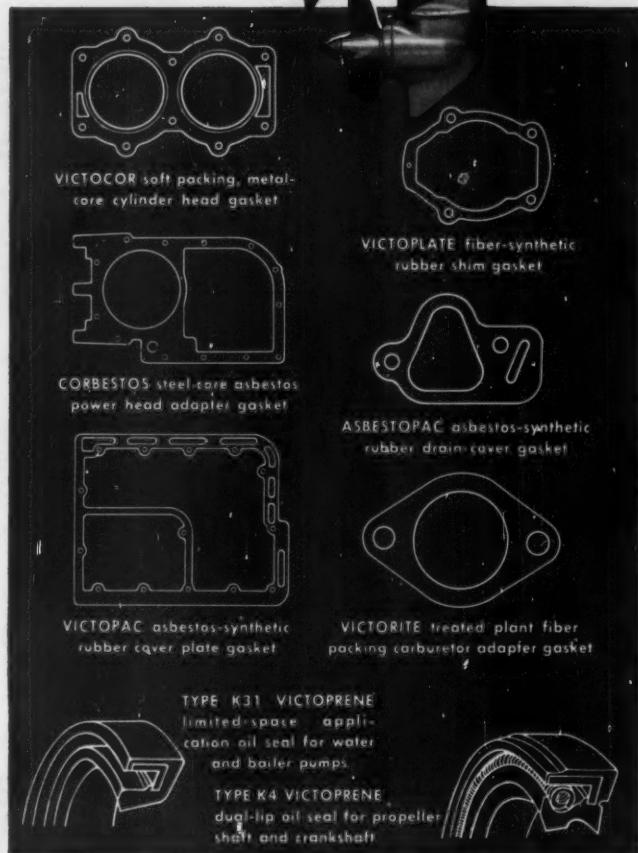
Sealing specifications play no small part of Scott motor dependability. For maximum power output . . . efficient carburetion and cooling . . . tight lubricant retention and water exclusion . . . heavy emphasis is placed on high-quality gaskets and oil seals.

Engineered Sealing—a Victor Specialty

For marine power units as for all types of engines, machinery and appliances, Victor sealing assures dependable, economical sealing. In standard gasket and oil seal designs, Victor's complete lines provide the widest selection. For nonstandard needs, 50 years' experience in designing and manufacturing to specification is at your service.

Write for New Catalogs

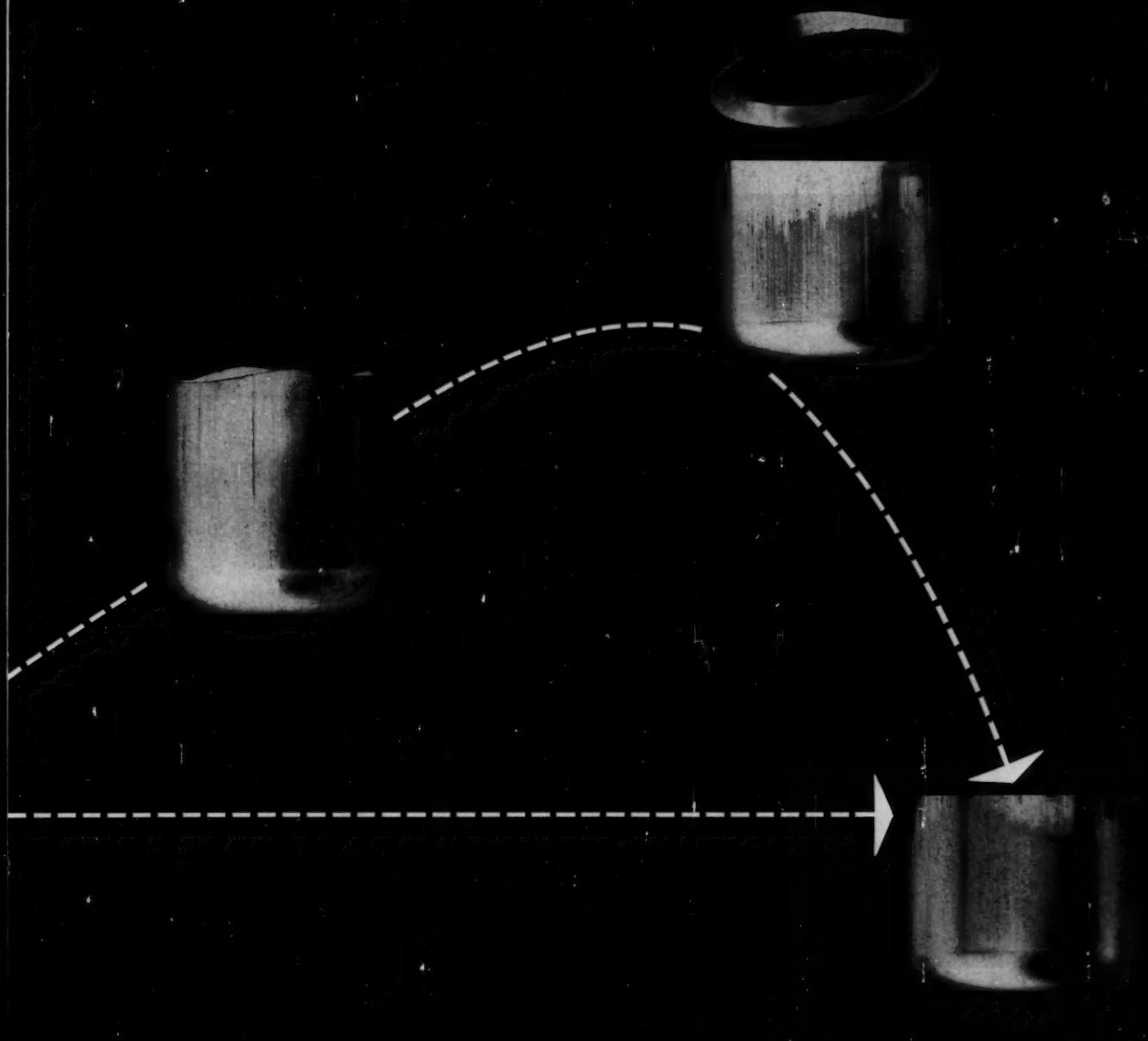
Comprehensive engineering catalogs for sealing specifiers are available through your Victor Field Engineer, or by letter request. Please state whether interested in gaskets or oil seals—or both. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90. Canadian Plant: St. Thomas, Ont.



VICTOR

Sealing Products Exclusively

GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS



ARE YOU TAKING THIS COSTLY PRODUCTION "DETOUR"?

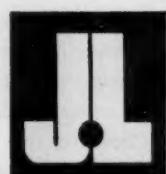
The problem is a common one in steel drawing operations: How to eliminate scalloping or "ears"?

One way is to trim them. The other is to eliminate them—at the purchasing stage.

You can do this by specifying J&L Precision Non-Scalloping cold rolled strip steel. Through precise control of every production step, J&L has developed a low carbon strip which is *non-scalloping*.

Result: a major operation—trimming—can be saved. Also, you'll have fewer rejects and less down-time. These advantages mean more profitable production—and are especially important in operations involving progressive dies, where uniformity and protection of equipment are major factors.

Non-scalloping strip is just one of the full line of precision products backed by J&L's combination of specialized equipment and techniques, plus *experience*. For information, call your J&L Stainless and Strip Division representative or write to Dept. 1360.



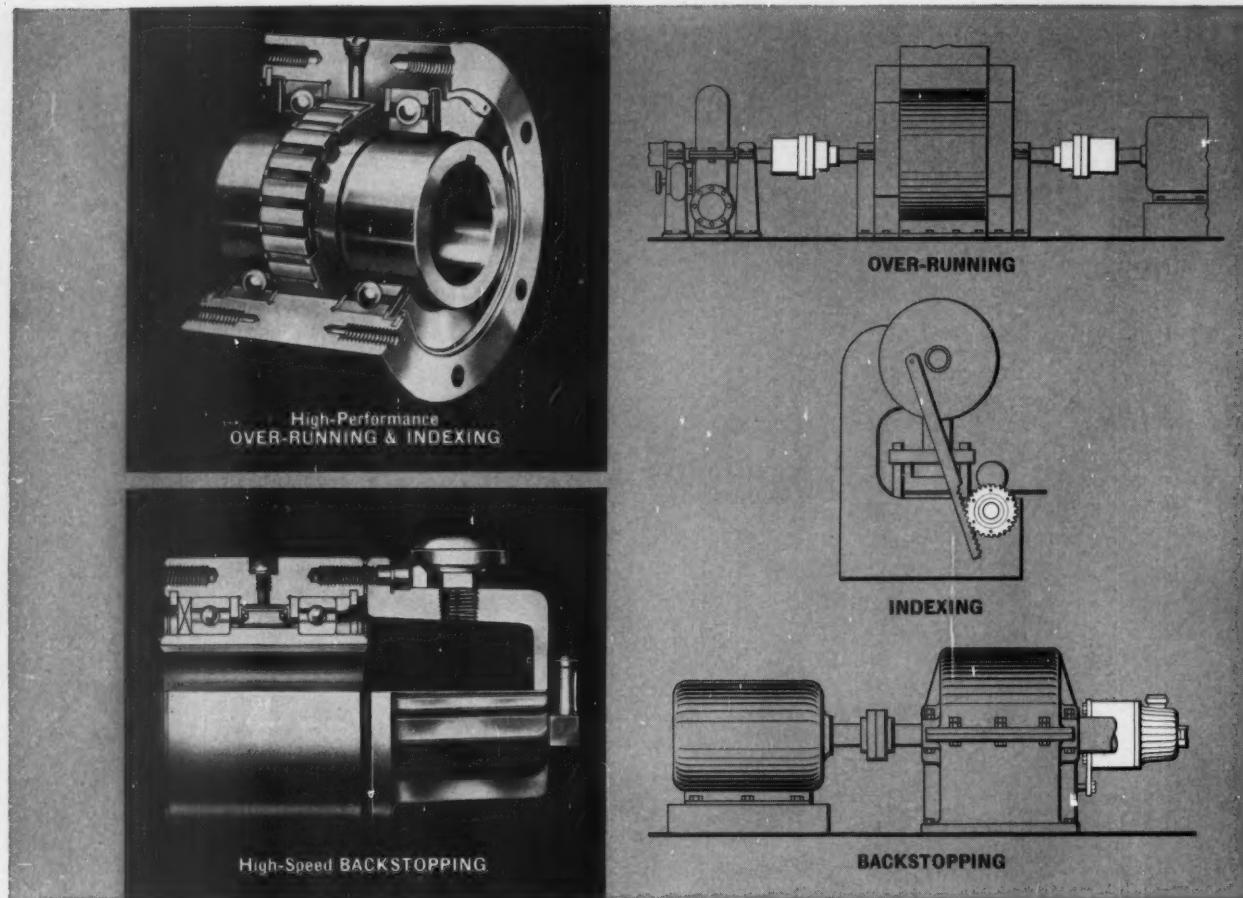
STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Circle 252 on Page 19

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

FORMSPRAG Clutches have



These Installations Prove Formsprag Has The Most Advanced Clutch Designs Available

On tough applications requiring high-performance over-running, indexing or backstopping, Formsprag clutches have *proved* their unusual durability, precision and reliability. Their long-life and minimum maintenance requirements, even under unusually demanding installation conditions, have provided many users with the answer to their clutch problems. Compare the following performance results on actual installations—Formsprag designs can help you, too!

High-Performance Over-Running

Application:
Forced and Induced Draft Fans.

Clutch and Mounting:
Model FO-732 Clutch-coupling (HPO-720 clutch with coupling) mounted on fan drives.

Requirements:
Continuous over-running at 1200 to 1800 R.P.M. (24 hours a day, 365 days a year).

Proved Results:
The Formsprag HPO clutch design with Formchrome sprags provides this company with greater durability and less maintenance than any other available clutch. Therefore, on all forced and induced draft fans, this manufacturer specifies Formsprag high-performance over-running clutches.

Precision Indexing

Application:
High Speed Press.

Clutch and Mounting:
Model HPI-700 feeding a progressive die.

Requirements:
20° indexing; feed is 700 strokes per minute; accuracy of feed must be within .005"; press operates 24 hours a day, 5 days a week.

Proved Results:
After poor service life and unreliable results from other clutch designs, a Formsprag high-performance indexing clutch was installed. Result—customers requirements for accuracy were met, clutch has had a life of 80 million cycles, and is still running.

proved higher performance

(GREATER TORQUE & SPEED, HIGHER PRECISION, LONGER LIFE)

During the last two years, Formsprag has announced several major advances in over-running clutch design. These advanced concepts have been widely accepted by designers of modern power transmission systems. The high performance results they obtained on over-running, indexing and backstopping applications prove Formsprag clutches to have the most advanced designs available.

On-the-job records prove these high performance characteristics: (1) Formchrome sprags, with high-hardness and wear resistance, provide exceptional durability—no other manufacturer can offer the performance advantages of Formchrome sprags. (2) The improved sprag and retainer design of Formsprag High-Performance Over-running (HPO) and Indexing (HPI) clutches permit up to 30% higher operating speeds with same life span and up to 70% longer clutch

life when operated at same RPM as ordinary clutches. (3) On backstopping applications, the High-Speed Backstopping (HSB) clutch design permits higher speeds, assures longer life and reduces maintenance to a minimum.

Specific case-history data on *proved* over-running, indexing and backstopping installations is provided below. In every instance, users of Formsprag High-Performance Clutches have found the answers to problems of wear, high-speed operation, precision and maintenance.

There is a Formsprag Clutch for every application. Standard models include: sleeve bearing, ball bearing, miniature, large-bore holdbacks, and high-performance types. For special applications, Formsprag engineers will recommend a modified standard clutch or design a special. Standard clutches are fully described in the Formsprag catalog—send for your free copy.



ORMSPRAG COMPANY

23603 Hoover Road, Dept. 114-A — Warren (Detroit), Michigan

Representation Throughout The World • Precision Power Transmission Products

High-Speed Backstopping

Application:
Iron Mining (Taconite) Conveyor.

Clutch and Mounting:
Model HSB-700 clutch assembly mounted on high-speed shaft of reducer.

Requirements:
In abrasive atmosphere, clutch must over-run at 1200 to 1800 R.P.M. (24 hours a day, 9 months of year).

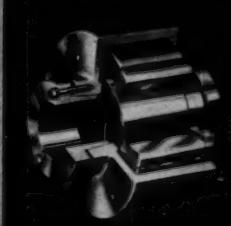
Proved Results:
On this rugged backstopping application, Formsprag HSB clutches solved problems of overheating, premature seal wear, and short clutch life. These high-speed backstopping clutches have been in operation for over a year and are still delivering their initial high performance.

OTHER FORMSPRAG PRECISION PRODUCTS

NEW RAWSON

CENTRIFUGAL CLUTCHES and CLUTCH-COUPPLINGS

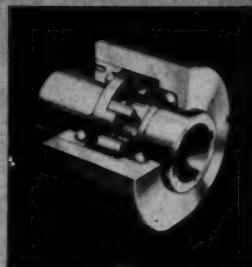
Used in a wide variety of applications, the Rawson design provides no-load starts for motors and cushioned starting of driven equipment. They permit using smaller motors and across-the-line starting.



REVILOK

DUAL TORQUE-LOCKING and POSITIONING DEVICES

These multi-purpose devices stop feedback torque and provide two-directional positioning, over-running, backstopping and load-limiting. They can also be adapted for single revolution and torque-limiting functions.



jamesbury "Double-Seal" BALL VALVES*

TM
*PATENTED

AS VERSATILE AS INDUSTRY ITSELF

The illustration below gives you a glimpse of the depth of application of the versatile Jamesbury "Double-Seal" Ball Valve.

For on-off, quarter turn, full flow, leakproof, maintenance-free operation, no valve can match the exclusive Jamesbury "Double-Seal" action.

We will welcome an opportunity to prove this statement, whatever your valving requirements might be.



JAMESBURY CORP., 70 NEW STREET, WORCESTER, MASS.

DISTRIBUTORS IN PRINCIPAL CITIES

© 1961 Jamesbury Corp.

403-0

1. Standard flange with PC 50 operator.
2. Screwed end type.
3. 6" flange with ST 490 operator.
4. 6" flange for manual operation.
5. PVC screwed end type.
6. Screwed end with EM 25.
7. Screwed end with PC 50 operator.
8. 2" flanged valve.
9. PVC flanged valve.

MATERIALS:

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.

SIZES:

Screwed End: 1/4" through 3".

Flanged

150# series —

1/2" through 12".

300# series —

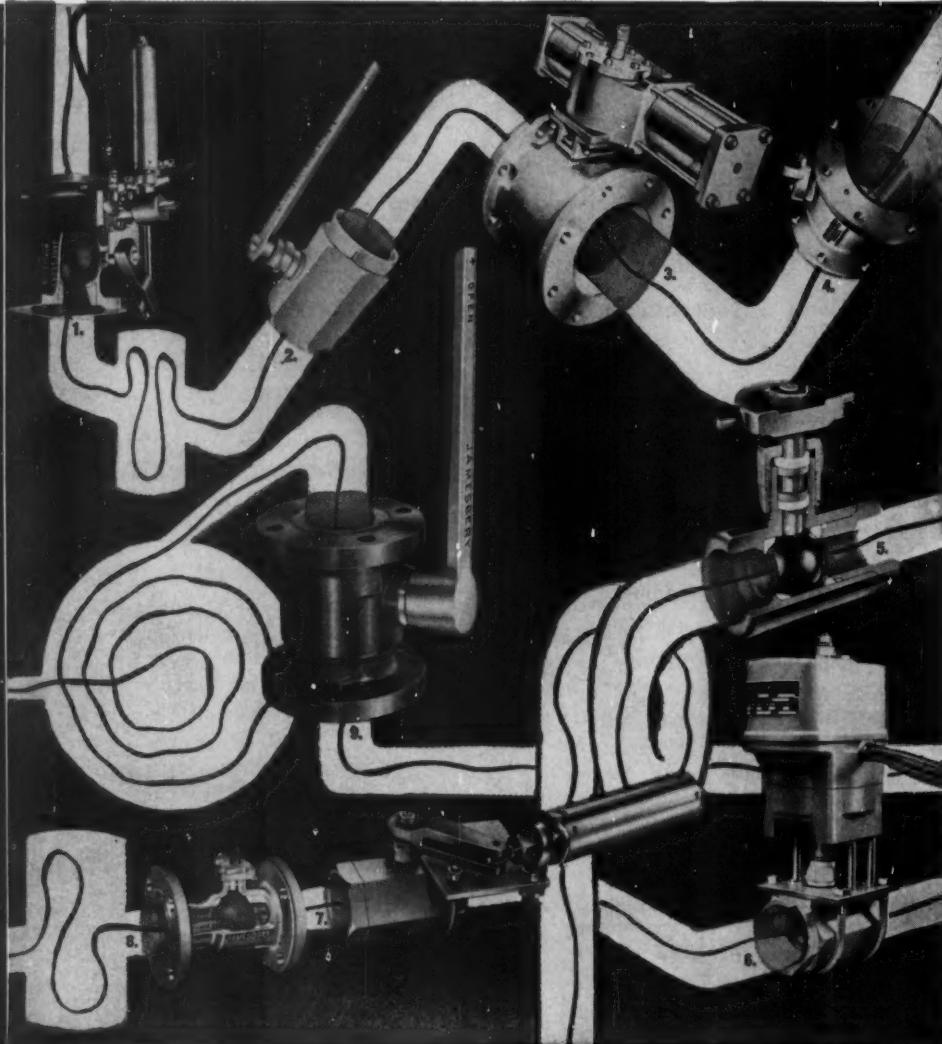
1/2" through 8".

*10" and 12"

on application

*600# series

on application





Shell Tellus Oils are refined and formulated to meet exacting hydraulic service requirements, such as in this forming machine.

PHOTO COURTESY ATLANTIC PLASTICS INC., STAMFORD, CONNECTICUT

BULLETIN:

Shell provides a quick 6-point check list for hydraulic oils: Use it to pick the right oil for your needs

Selecting the proper hydraulic fluid for your equipment can be one of your most important decisions. And it can pay off in many ways. Less down time. Lower cost per unit. Longer equipment life.

Here are six bench marks to help you pick the best hydraulic oil for your plant requirements.

1. Does it have good oxidation stability? Oxidized hydraulic oil can form gums, lacquers and other deposits which may foul moving parts. Shell Tellus Oils are carefully refined to remove unstable, sludge-forming components, then fortified with a Shell-developed oxidation inhibitor.

2. Will it resist foaming and emulsification? Pump chatter and erratic operation are often the result of pump cavitation, brought on by oil foaming. Tellus® Oils contain powerful additives to help prevent foaming.

They also contain a selected inhibitor to combat effects of moisture that might be in the system.

3. Does it fight rust and corrosion? It is difficult to exclude all moisture

from a hydraulic system. And moisture can form troublesome rust. Shell Tellus Oils have been carefully compounded to resist corrosion.

4. What are its lubrication qualities in continuous service? Shell Tellus Oils form a clinging, oily film on mating metal surfaces. This maintains a constant guard against wear.

5. How does it react to temperature changes? This is a key factor in the performance of hydraulic equipment. Careful selection of the proper viscosity grade of Tellus assures satisfactory operation of your system over its entire temperature range.

6. Is it available in several viscosity grades? Shell Tellus Oils are available in a broad range of viscosity grades.

There's a special grade for virtually every hydraulic requirement.

Ask your Shell Industrial Products Representative for facts on Tellus Oils. Or write: Shell Oil Co., 50 West 50th St., New York 20, N. Y.

A message to manufacturers of hydraulic equipment

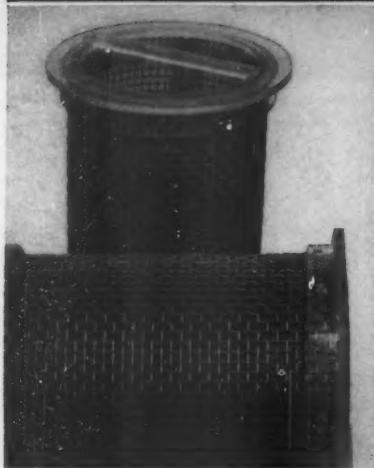
There is a Shell Tellus Oil suited for your equipment.

1. Your customers can get Tellus Oils at Shell depots everywhere. Readily available throughout the world.
2. Quality is consistently high. Tellus always delivers top performance.

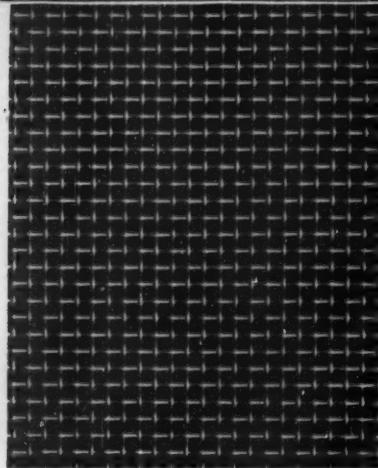


A BULLETIN FROM SHELL
—where 1,997 scientists are working to provide better products for industry

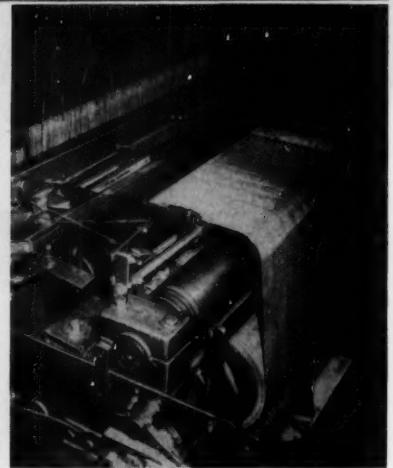
Need Wire Cloth in Special Metals? call Cambridge



HASTELLOY C*



SILVER



TITANIUM

Working with unusual metals or alloys—as well as with standard metals and alloys—is almost an everyday occurrence at Cambridge. For instance, not too long ago, we developed the first practical method of weaving titanium into wire cloth—with mesh counts far higher than had been expected by the customer. Platinum, lead, stainless steel, or bronze—whatever the metal or alloy used, Cambridge has the experience and facilities to produce wire cloth in any size or quantities to the closest tolerances.

If you require fabrications—of any shape or size—Cambridge has the craftsmen and know-how to fill even the most rigid specifications. Or, we'll draw up prints for your approval. There's a wire cloth expert near you—ready to discuss your needs and show you how to get what you want economically and on time. He's your Cambridge Field Engineer...and his name is listed in the Yellow Pages under "Wire Cloth." Or, write for our illustrated, 120-page catalog.



Refer to our technical data sheets in **CHEMICAL ENGINEERING CATALOG, Page 185**



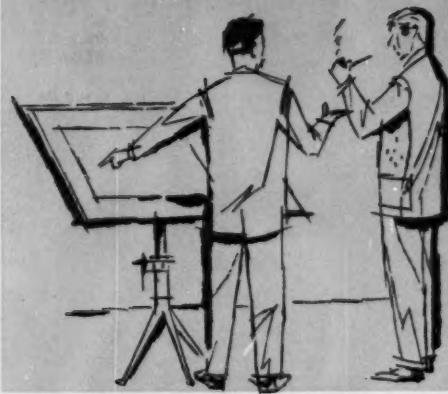
The Cambridge Wire Cloth Co.

DEPARTMENT N • CAMBRIDGE 4, MARYLAND

Manufacturers of Wire Cloth, Wire Cloth Fabrications, Metal-Mesh
Conveyor Belts and Gripper® Metal-Mesh Slings.

*Reg. T.M. of Union Carbide Co.

WANT TO CUT YOUR SHAFT SEAL COSTS? TRY THIS APPROACH...



For example, why design a shaft seal engineered to last 10 years into a piece of machinery designed to last only 5 years? That seal costs too much for its application.

Research indicates that more than 50% of the face-type shaft seals in use today are "over-designed." Gits Bros. are specialists in cutting costs by eliminating such over-design, in part by proper use of a broad selection of newly developed materials.

It costs you nothing to let the Gits Engineering Staff check *your* face-type shaft seals for over-design, and you may stand to realize significant savings in costs.

Whether your product is still on the drawing board or already in production, or if you use seals in Field Service Kits, just send us full details of the shaft seal application. Every day you delay sending this information can pile up those extra costs.

GITS BROS. MFG. CO.

1868 South Kilbourn Avenue • Chicago 23, Illinois

Specialists in
Lubricating Devices
and Shaft Seals
for Over
Half-A-Century

Here's Take-Your-Choice Versatility

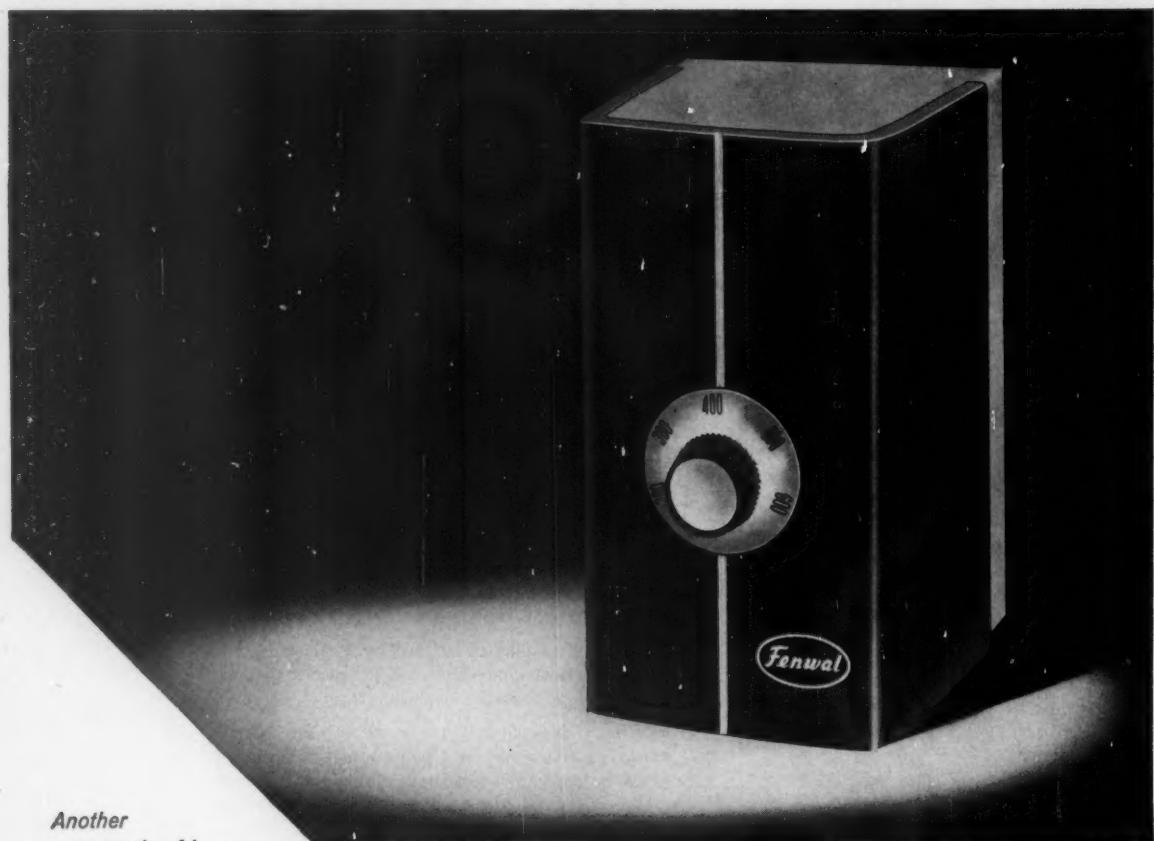
*with the Multi-option Fenwal
536 Temperature Controller*

It's so *precise* and yet so *easily adaptable* to an almost endless variety of temperature control applications, you become all but convinced that the transistorized Model 536 was engineered with only your needs in mind!

From its multi-option printed circuit board to its numerous interchangeable components, the Model 536 Temperature Controller spells *versatility*. ON/OFF or proportioning control . . . dial for set point adjustment mounted externally or internally . . . expanded scales for precise temperature adjustment — the 536 offers all these advantages! Five standard temperature ranges from -50 to +600°F . . . separate potentiometer with graduated dial and knob for remote temperature adjustment . . . capacity of 10 amp/110 VAC and 5 amp/230 VAC . . . these choices are also available to you. *And you pay only for the options you need!*

The 536 is sensitive to within 0.1°F. And if you wish to build a multi-point control and indication system — either gradually or all at one given time — you simply combine the Fenwal Model 580 Temperature Indicator with as many 536 Controllers as you require. Thermistor sensors enable fast response and ordinary copper lead wire may be used for connections. Removable interior of the Model 536 allows easy, safe installation and the instruments are smartly styled to perfectly complement modern industrial machines and interiors.

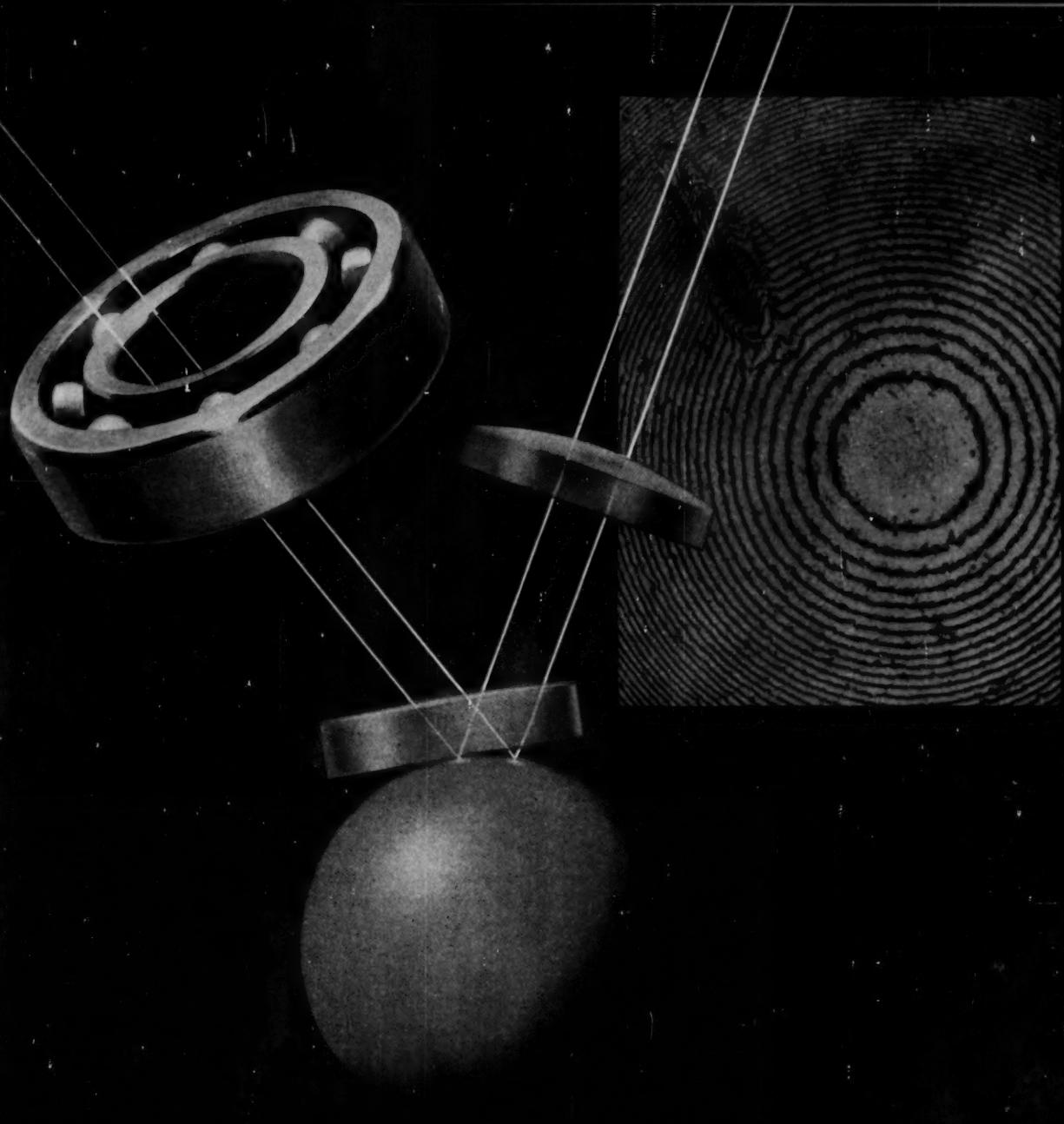
Find out more about how the precise Model 536 Temperature Controller can be adapted to your exact needs by writing to FENWAL INCORPORATED, 194 Pleasant St., Ashland, Mass. Request Bulletin MC-195.



*Another
example of how*

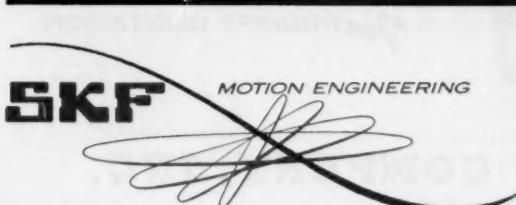


CONTROLS TEMPERATURE . . . PRECISELY



SPLIT LIGHT BEAMS MEASURE IN MILLIONTHS

to help **SKF** build better bearings



Advanced ball and roller bearing technology

The concentric pattern of interference fringes in the picture above is reproduced from an actual photo taken with the aid of an interferometer in the **SKF** laboratories. The subject under examination is a microscopic flaw in the surface of an accurately lapped steel ball. The principle of utilizing split beams of light to form interference patterns enables accurate measurements to be made in *millionths* of an inch.

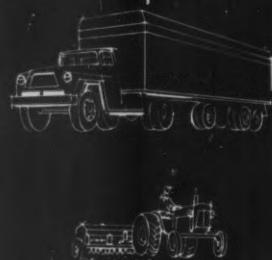
SKF is a leader in the development and application of ultra-precise measuring systems. The **SKF** metrology laboratory plays an important part in a continuing program of research to produce bearings of improved accuracy and finish, and consequently, quieter, smoother running characteristics.

Whatever types of rolling contact bearings you need—ball, cylindrical roller, spherical roller, tapered roller or precision miniature—you'll find **SKF** your best assurance of dependable performance. **SKF** Industries Inc., Philadelphia 32, Pa.

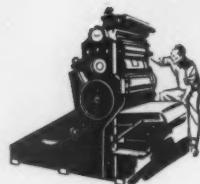
6104

Circle 259 on Page 19

Busiest IN ANY BUSINESS



US Custom
engineered
SHAFTS



Write for this handsome brochure about U. S. Axle —
FREE on REQUEST



precision-made of finest steels to
work better . . . last longer!

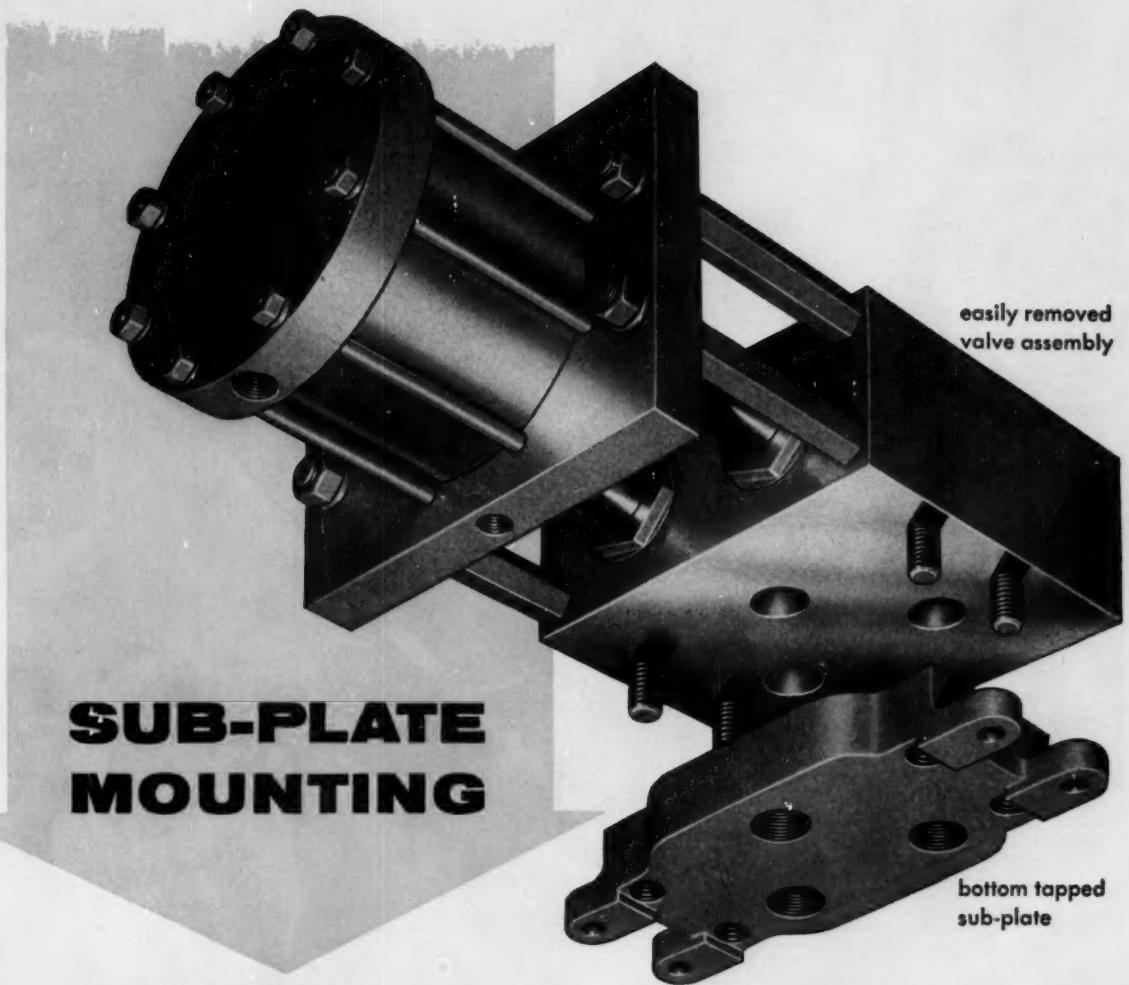
OVER 40 YEARS of specialized shaft "know-how" enables U.S. Axle to produce *exactly* the shafts you need, quickly and efficiently. Every phase of their precision processing — from raw material to scientific heat-treating and shot-peening for added toughness — is keyed to meeting your most exacting requirements. For top performance on any shaft application in your product, specify U.S. *Custom-Engineered Shafts*.

SUBMIT YOUR PRINTS
AND SPECIFICATIONS
For PROMPT QUOTATION

THE **US**[®]
AXLE COMPANY, INC.

Since 1920 • Pottstown, Pennsylvania

Circle 260 on Page 19



SUB-PLATE MOUNTING

for HUNT Hydraulic Valves

- **easier maintenance**
- **minimum downtime**

Designed to fit into today's preventive maintenance programs, Hunt's new sub-plate mounting permits quick valve removal and installation.

With sub-plates, equipment downtime is cut to an absolute minimum . . . valves can be repacked in your maintenance shop instead of on the machine. And, once installed, permanent piping need never be disturbed.

O-ring seals between valve body and cast steel

sub-plate assure leak-free sealing . . . bottom tapping of sub-plate affords maximum access to valves and eliminates piping clutter.

Sub-plate mounting is available on all 1/2 through 2 in. Hunt hydraulic valves.* To learn more about the performance and cost-cutting advantages of Hunt valves, contact your nearby Hunt representative.

*Except those with cast or forged bodies.

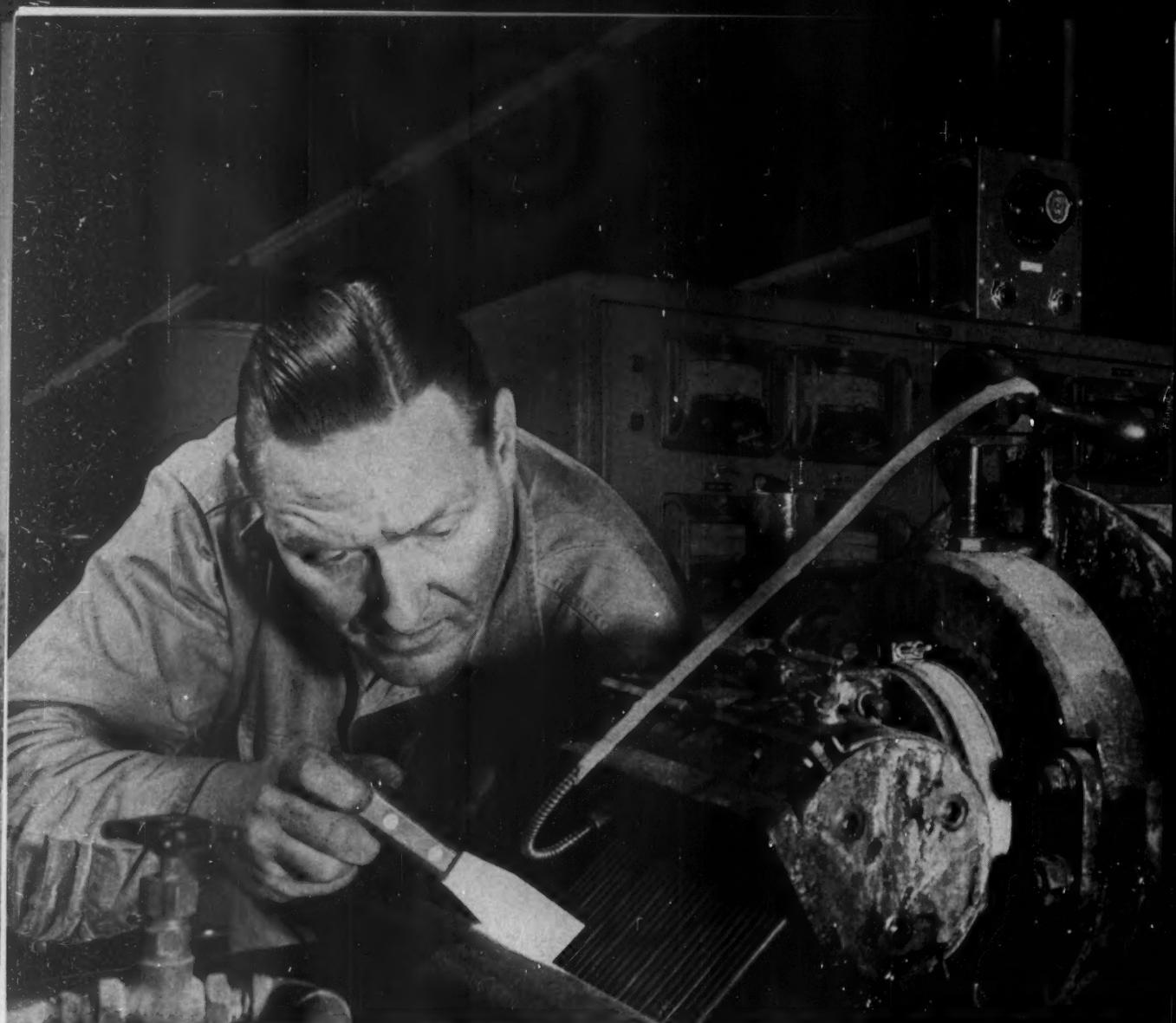
HUNT

QUICK-AS-WINK® AIR AND HYDRAULIC

VALVES

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

Want more detailed information? Write Dept. MD-461,
Hunt Valve Company, Salem, Ohio. Ask for Bulletin 604.



THE TURN OF ONE DIAL MATCHES PROCESS SPEEDS TO CHANGING PRODUCT DEMANDS

The value of the Reliance Super 'T' V★S Drive on this extruder is in its ability to produce and hold accurately the wide range of specific speeds necessary to handle a variety of plastic materials.

Polyethylene, polystyrene, nylon and PVC are among the plastics that are color-compounded, heated and extruded for pelletizing. Each one calls for a different machine speed and setting. Motor operating speeds can be varied from 145 to 2000 rpm . . . and within

the range, the V★S Drive maintains the exact speeds needed to extrude and pelletize each type . . . and this even includes zero speeds for set-up.

These perfectly controlled speeds and the 24-hours-a-day, 7 days-a-week use demanded by this plant's production schedule are the basic reasons why Plastic Materials and Polymers, Inc. has standardized on Reliance V★S Drives in all three of its plants.

BUILDERS OF THE TOOLS OF AUTOMATION

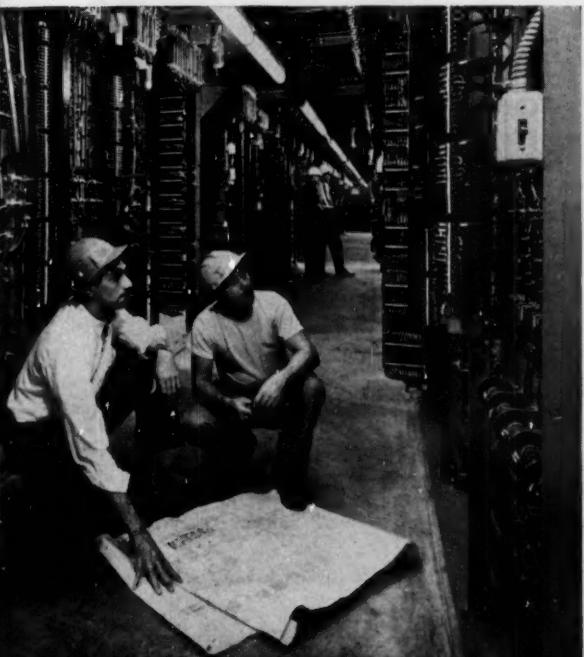
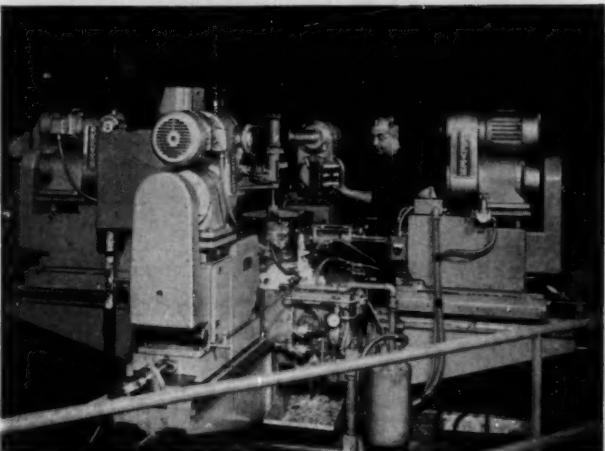
ONE SELF-CONTAINED, COMPACT POWER PACKAGE. This MASTER GEARMOTOR has been operating outdoors for 5 years regardless of weather. It has no exposed high speed couplings, no V-belts, chains or sprockets. Engineering and assembly costs are reduced. You can simplify installations and save space with vertical, horizontal and flange mountings; output shaft over, under, left or right. Ratings 1/8 to 125 hp. in right angle, parallel or in combination. Right angle ratios are available up to 96:1; parallel 120:1. Bulletin E-2409.



CONTOUR EPOXY-COATED TO ELIMINATE ENCAPSULATION CRACKING. New RELIANCE ENCAPSULATED MOTOR . . . gives you positive protection from dust, dirt, acid and water. Unlike other heavy molded coatings, stator windings are vacuum-impregnated with epoxy resin at a uniform thickness, follow the contour of the windings. You get maximum flexibility, tensile and bond strength, plus quicker cooling . . . all vital to superior motor performance. Bulletin B-2108.



INFINITELY VARIABLE OUTPUT SPEEDS AT LOW COST. REEVES MOTODRIVES, shown here powering this 4-position drilling and boring machine, are used extensively for hundreds of production needs. Horsepower ratings from $\frac{1}{4}$ to 40, speeds from 1.71 to 4660 rpm. Speed variation ranges from 2:1 to 10:1. Available in hundreds of space-saving assemblies . . . with manual, remote or automatic process control (Airtrol). Bulletin M-592.



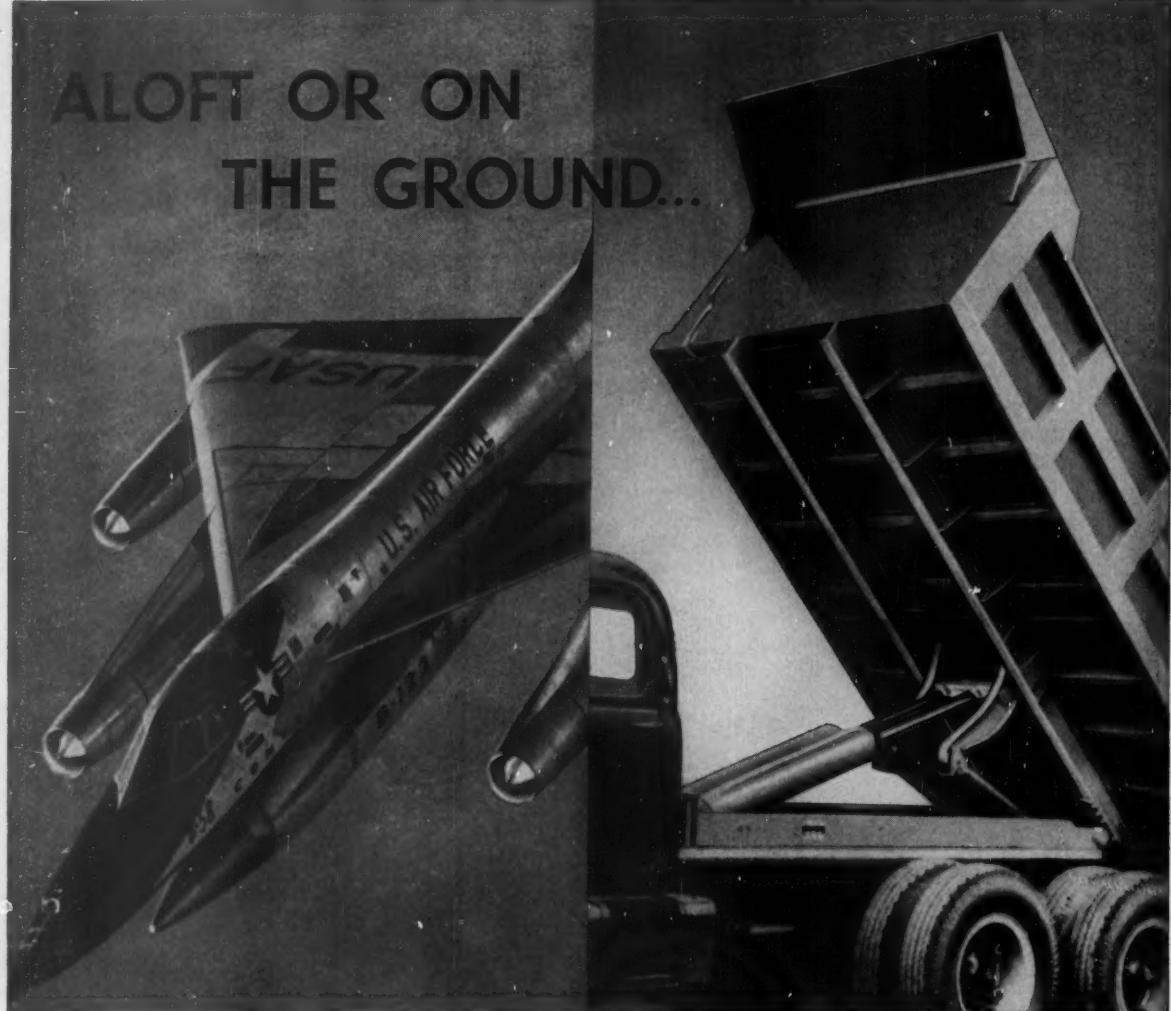
TOTAL SERVICE is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.

RELIANCE ELECTRIC AND
ENGINEERING CO. •

DEPT. 284A, CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont.

Circle 262 on Page 19

ALOFT OR ON
THE GROUND...



Koppers Sealing Rings give ensured actuation!

Koppers solves diverse and difficult sealing problems.

Modern supersonic jets and dump trucks—as dissimilar as they appear—both depend on Koppers Sealing Rings for efficient hydraulic system operation. Koppers *Predictable Performance* Sealing Rings are used in a wide variety of applications . . . engineered to satisfy each requirement of both hydraulic and pneumatic sealing.

Koppers has the technological skill, gained through 38 years of experience, to meet the most critical performance requirements in any sealing application. Look to Koppers to solve your sealing problems. For an informative booklet on Metallic Sealing Rings write to: KOPPERS COMPANY, INC., 6504 Hamburg Street, Baltimore 3, Maryland.



A Koppers Sealing Ring is applied to a B-58 actuator.



SEALING RINGS
Engineered Products Sold with Service

Circle 263 on Page 19

Circle 264 on Page 19→



HOW KEYSTONE WIRE

adds Sales Appeal

to bobby pins...

To manufacture millions of identical bobby pins, Sta-Rite Ginnie Lou, Inc., Shelbyville, Illinois, needed a high quality spring wire that would perform consistently with long runs in their high-speed automatic wire forming machines.

For extra "sales appeal", Sta-Rite Ginnie Lou specified a wire with superior surface that would take an attractive finish to please discriminating women. It had to have high test flex and maximum spring back qualities. This called for uniform temper and close diameter tolerance throughout the coil.

Keystone Metallurgists, in close cooperation with Sta-Rite Ginnie Lou, developed a white liquor finish, high carbon *completely clean* spring wire with all these qualities. The large coils are specially packed with rust preventive in payoff packs for long trouble-free runs.

Says Vaughn C. Wallace, Vice President in charge of manufacturing, "Keystone Wire, with its superior finish, produces a bobby pin which meets our high standards of quality and ready acceptance in thousands of outlets across the nation." Keystone's excellent wire forming features are the result of accurately controlled thermal treatment and correct chemical analysis to provide the right structure for this difficult cold rolling and forming operation.

Keystone Wire Specialists can produce a wire for your most exacting specifications. Contact your nearest Keystone Wire Representative soon. Or write us concerning your wire problems.

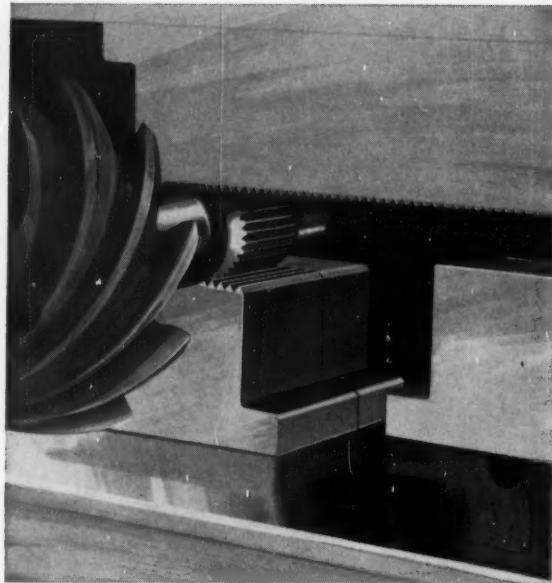
Keystone Steel & Wire Company, Peoria, Illinois



KEYSTONE

WIRE FOR INDUSTRY
MANUFACTURED AT PEORIA, ILLINOIS, U. S. A.

WHAT "CHIPLESS MACHINING" DOES FOR PRODUCT DESIGN



ROTO-FLO cold forming . . . chipless machining . . . offers the designer 9 ways of improving his product and cutting its cost as compared with conventional machining of similar parts:

GREATER STRENGTH . . . Since the ROTO-FLO process produces finished shapes by displacing the metal (cold working), density of grain structure is increased. Permissible torque loadings of shafts, for example, are increased about 50% when processed in this manner instead of being machined.

HEAVIER LOADS . . . For an equal 'finished' diameter, the higher strength permits increased loads. On toothed parts, tooth shear strength is increased 15% to 35% due to the improved grain structure and higher density.

LONGER FATIGUE LIFE . . . The cold working operation not only increases density of grain structure, but produces a better grain flow and reduces stress concentration. There is thus greater freedom from fatigue failure. Permissible torque loadings for shafts, are increased over 50%.

LESS WEAR . . . Wear is decreased because of the improved grain structure, higher density and finer finishes obtainable.

LESS BACKLASH . . . The original fit of ROTO-FLO processed parts prevails over longer periods due to the finer surface finish and decreased wear.

FINER FINISH . . . Finishes as low as 3 to 6 micro-inches are being obtained in routine production with the ROTO-FLO process. The long tool life assures retention of accuracies within ASA specifications over long runs.

LESS MATERIAL . . . Since the process displaces metal outwards, increasing the final diameter, the blank—for the same minimum cross-section of the finished part—can be of smaller diameter. In addition, it is sometimes possible to reduce the finished OD of the part (as compared with a machined part) because of the higher inherent strength of the cold-worked part. In any event, you use *ALL* the material you start with instead of wasting a lot in the form of chips.

LOWER COST . . . In addition to the materials savings made possible by reduction in blank size, the ROTO-FLO process usually reduces tool cost far below that required when machining the same part. Further, the extreme rapidity of the process (up to 30 times faster than cutting) permits greater production per machine hour.

DESIGN FREEDOM . . . Cold forming . . . instead of cutting . . . opens new horizons for improved design of parts lending themselves to ROTO-FLO processing. Part designs can often be simplified. Shoulders present less of a problem.

WHERE YOU CAN USE IT

The ROTO-FLO process is ideally suited for the production of parts which require splines, threads, grooves, serrations, etc. Splines may be tapered or straight, spur or helical. Splines and threads or grooves on the same part usually can be produced in a single operation. Parts may be of a wide range of materials—from SAE 1040 to Nitralloy to heat-treated stainless, plus brass, aluminum, etc.

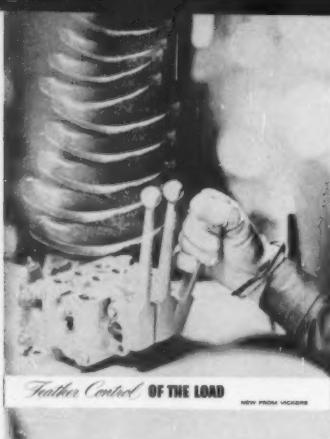


Let us help you improve your product and cut costs at the same time. Ask for Bulletin RF-60, Michigan Tool Company, 7171 E. McNichols Rd., Detroit 12, Michigan.



Feather Control **OF THE LOAD**

NEW FROM VICKERS



New Vickers Directional Valve Outperforms All Others

Greater capacity, improved metering provides smooth, precise, jerk-free load control never before possible . . . many other benefits, too.

TO manufacturers of materials handling, construction and other hydraulically operated mobile equipment, the new design of the Vickers CM11 valve offers startling opportunities. Truly a customer and market oriented product design, it meets all basic needs of the changing mobile equipment industry today and for the foreseeable future. In some cases it permits equipment progress previously impractical. To highlight a few benefits of the new CM11 design:

2500 psi OPERATING PRESSURE

The new CM11 Series valve offers the highest operating pressure for its size in the industry . . . 2500 psi! Yes, this greater pressure is practical without increasing over-all dimensions, thus making the new design completely interchangeable with previous Vickers models. Even though more force is available to do more work because higher pressures can be handled, standard high pressure fittings and hoses are currently available to meet system requirements.

NEW LOW PRESSURE DROP

The new Vickers CM11 series design has substantially reduced pressure drop at all rates of flow . . . 25% less drop! As an example, pressure drop of these units at 15 gpm is no greater than on former Vickers designs at 12 gpm . . . even less than that of other designs! (see Fig. 1)

This means more work capacity on every type of equipment with less horsepower wasted in the valve itself. Less heat is generated at the valve and, on electric trucks, valuable battery ampere-hours are conserved to do useful work.

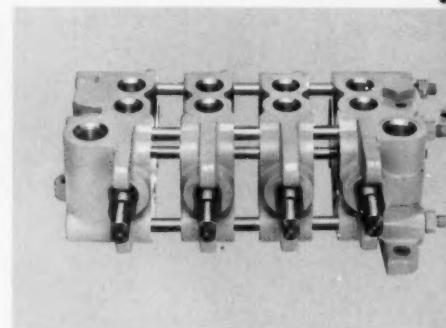
FINEST METERING YET

Due to design changes incorporating a new specially-developed casting, new Vickers CM11 valves feature the finest metering characteristics ever achieved. The result is true feather control of the load at all times . . . the jerky, rough control of all other valves is now a thing of the past.

This improved metering is the result of a number of material and design factors which give smoother spool action under all conditions and much more precise control of oil flow.

FLEXIBLE INSTALLATION

The new CM11 valves are completely



interchangeable with previous Vickers models. And still featuring multiple unit construction (a Vickers first) you can assemble as many control units as you need . . . even add to them later in the field.

NO HIGHER PRICE

All the advanced features above, along with many more not covered here, all are available without any increase in price! Improved manufacturing techniques, new tooling and increased demand give you the greatest value in valves ever offered.

FOR FULL FACTS

To get all the facts, all the features, all the answers to your own valve requirements simply write, or wire collect, to address below. Ask for Bulletin M-5112.

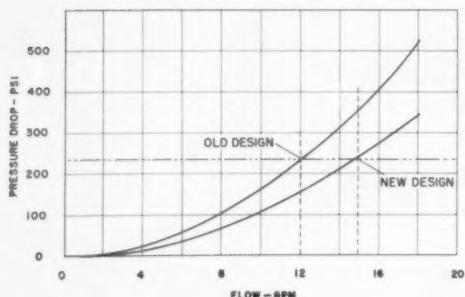
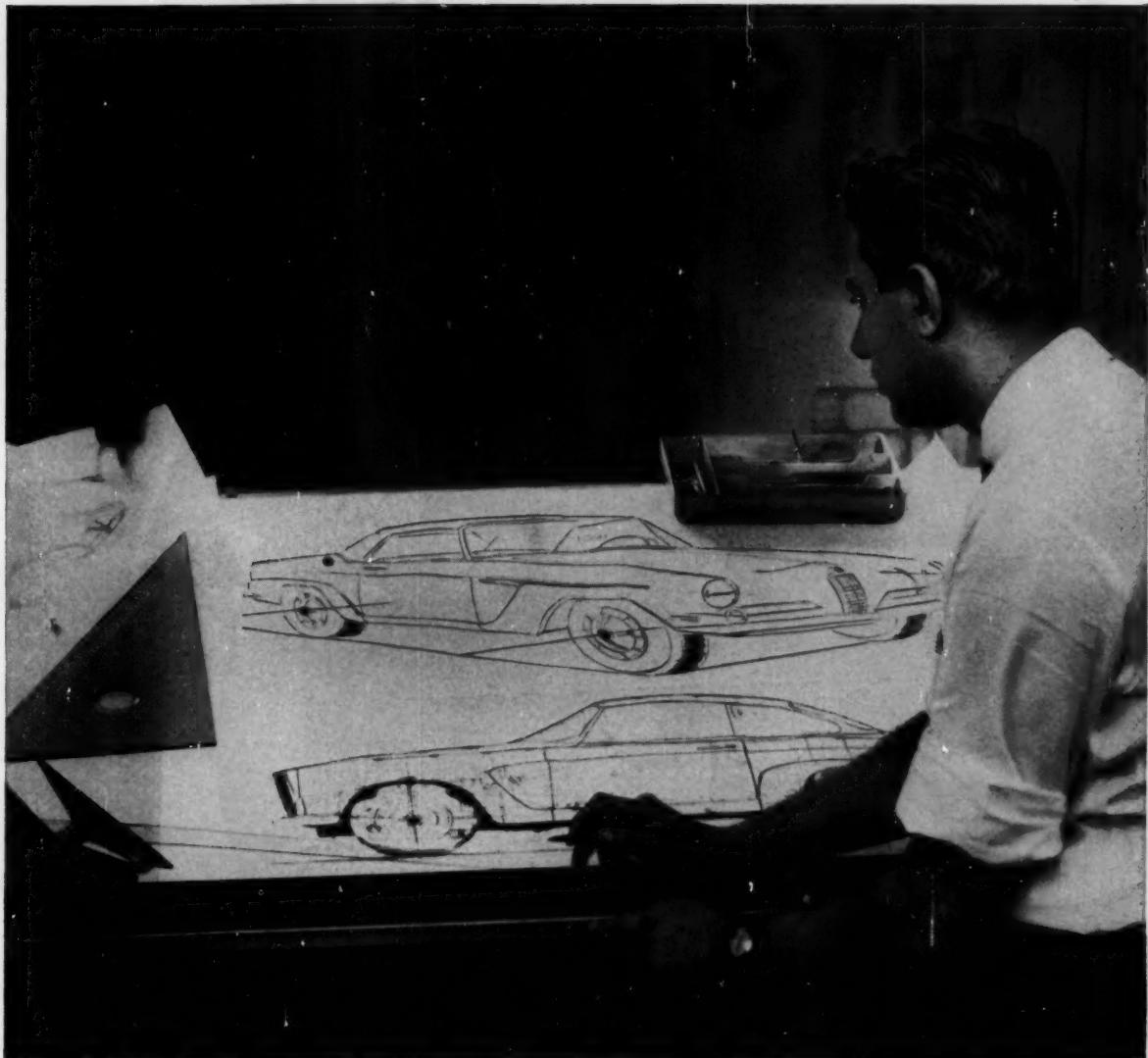


Fig. 1

VICKERS
VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE AND ENGINEERING CENTER
DETROIT 32, MICHIGAN, U. S. A.

WHAT'S NEWS IN RUBBER



In design after design...the big switch is to BUTYL!

Automotive engineers have discovered that Enjay Butyl rubber is one of the best ways to improve car performance. Now all U.S. cars contain parts made from Enjay Butyl... parts such as weatherstripping, body mounts, engine mounts, radiator hose, accelerator pedals, and many more. Engineers specify Enjay Butyl rubber because...

- *Butyl resists weathering*
- *Butyl deadens noise and vibration*
- *Butyl absorbs shock*
- *Butyl beats the heat*
- *Butyl resists tear, flex and abrasion*

Enjay is always ready to help manufacturers build the extra performance of Butyl into their cars. For more

information, contact Enjay's Detroit Area Office, 17360 West Eight Mile Road, Southfield, Mich. Phone KEnwood 2-7113.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

←Circle 266 on Page 19

Circle 267 on Page 19



FOR THE MACHINERY PART



THAT TAKES THE BEATING



HAYNES Alloys *will do the job!*

Perfect performance for 100,000 hours at orange heat, in the combustion chambers of diesel engines, is quite an achievement. Yet it's the record of tens of thousands of special combustion cups of HASTELLOY alloy C in a well-known line of diesels.

The alloy was chosen for its unique high-temperature strength and corrosion resistance and its outstanding ability to hold heat.

These and other special properties are built into HAYNES alloys—to fit the particular needs of design and production engineers for machinery parts that must meet the roughest service conditions.

If you are designing such a part, investigate HAYNES alloys. There are more than 15 to choose from. They include HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

HAYNES ALLOYS

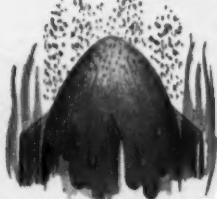
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana



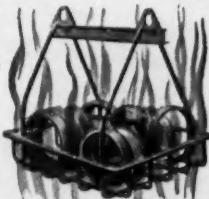
Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

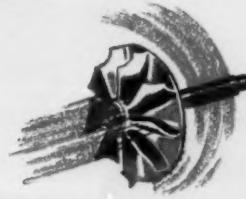
TYPICAL "HAYNES" ALLOY PARTS THAT RESIST...



ABRASION. Ten times the life and still no sign of wear, is the record of this plastics-extrusion torpedo nose made of HAYNES STELLITE alloy No. 3. This is one of many HAYNES wear-resistant alloys.



CORROSION. Baskets made of HASTELLOY alloy C used for holding forgings during acid treatment, are still good after 15 months of service. Materials formerly used were replaced every month.



HIGH TEMPERATURE. Turbine wheels in the "hot" ends of diesel engine turbochargers are investment-cast of HAYNES STELLITE alloy No. 31, for service at speeds up to 50,000 rpm. at 1500 deg. F.

"Our great new



'61 Mercs are built to give the finest performance in our history—so we naturally depend on G.S. Gears for our transmissions!"

"I say 'naturally', because G.S. Gears are old friends at Kiekhaefer. We've used several millions of them in the Mercury motors we've built in the last twenty-one years—and they've given us a remarkable record of trouble-free power transmission."

Positive power control has always been a big "Merc" feature, whether in full forward-neutral-reverse types like the new 70 hp Merc 700 and 80 hp Merc 800, or direct reversing engines, the 70 and 80 hp Merc 700 and 800; so they are mighty concerned with the way transmissions hold up in actual use—and you wouldn't believe the tasks some customers will set for their Mercs!

That's why Kiekhaefer is glad to know that they can keep counting on G.S. Gears for the same quiet, positive gear action their customers are used to. It's that kind of satisfaction that brings customers back

again and again when they're ready for new motors. Of course, this reliability means a lot to the plant, too. Production men know they can keep right on rolling without slowdowns—the G.S. Gear sets are *right*, and they're there when needed. You see, G.S. is strictly precision-minded—after all, we produce all kinds of gears from the hefty, heavy-duty bevels used in powerhouse outboards to tiny, delicate spurs for the most complex instrumentation. But we have production know-how, too, and the equipment and personnel to pour out gears in a continuous flow without wandering from specs. And G.S. experts are always available to work with your engineers on developing new ideas or better methods.

So, if your products involve small Gearing, you can't do better than to call in G.S. — it's great to have a source that keeps both your plant and your customers happy!

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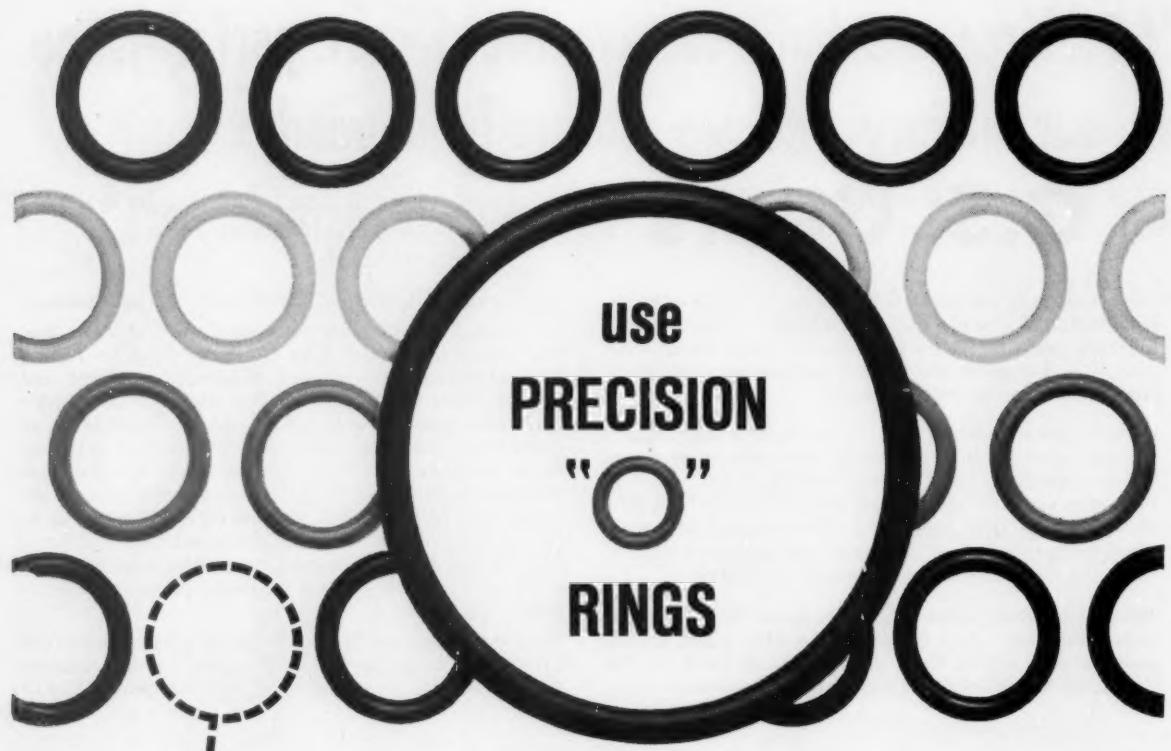


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before it starts!**

"Down time" costs money, whether it's on the assembly line, or after a product is in use. (The latter could be costly to future sales!) That's why you're money ahead when you use quality "O" Rings, made by Precision. They're rigidly inspected and tested over 100 times... They're made to do the job better... longer. Call a Precision Sales Engineer for help with your product design and the RIGHT Precision "O" Ring for your product. Write, wire, or phone today.

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60 Case

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parts by
conventional
methods!

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

ELIMINATE WEAR and REDUCE COST

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60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from $\frac{1}{4}$ " to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining. Write for literature and name of your local representative.

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Circle 271 on Page 19

PARTS HARDENED to 60 C...

increase life...reduce cost!



makes the blower you



VAX-4-FC

need!

	blower	nom. dia.	power	design point
	TAX-1-VS	1"	d.c.	10 cfm. @ 0.3" H ₂ O not pictured
	VAX-2-MM	2"	d.c.	37 cfm. @ 1.5" H ₂ O
	VAX-2-MC	2"	400 ~ a.c.	50 cfm. @ 2.1" H ₂ O
	VAX-3-BD	3"	d.c.	80 cfm. @ 1.2" H ₂ O
	VAX-3-FC	3"	400 ~ a.c.	100 cfm. @ 3.5" H ₂ O
	VAX-3-GN	3"	115v. a.c./d.c.	70 cfm. @ 1.5" H ₂ O
	VAX-4-FC	4"	400 ~ a.c.	95 cfm. @ 2.2" H ₂ O (140 cfm. @ 2.1" H ₂ O)*
	VAX-4.5-LC	4.5"	400 ~ a.c.	77 cfm. @ 5.0" H ₂ O (140 cfm. @ 5.0" H ₂ O)*
	VAX-4.5-GR	4.5"	115v. a.c./d.c.	220 cfm. @ 1.8" H ₂ O
	VAX-5.5-LC	5.5"	400 ~ a.c.	300 cfm. @ 3.0" H ₂ O
	STAX-3-FC	3"	400 ~ a.c.	30 cfm. @ 14.0" H ₂ O

*at 25,000 feet

most stocked for 24-hour prototype delivery

For any electronic cooling problem that comes down your road, look to Globe! This big new line of vaneaxial blowers may meet your need right now. Or Globe will design and develop a special blower for your application (it's not as difficult as you think). Because we make all kinds of motors, we can control all the variables—size, weight, high temperature performance, and MIL spec factors.

A.C. blowers are for 60,400 cycle, or variable frequency; a.c./d.c. blowers are for universal operation. Globe also makes a complete line of miniature centrifugal and tube-axial blowers and open fans. Request Bulletin VTC from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

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PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, CLUTCHES, BLOWERS & FANS, MOTORIZED DEVICES

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No doubt about it—it's important to keep correspondence carefully filed; but it is even more important to equip your drafting department with modern filing facilities that keep active and semi-active drawings readily accessible, fully protected—and in a minimum of space.



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Inadequate or antiquated equipment in your drafting room can cost you more money than you imagine in lost time, errors, done-over work, and low morale. Hamilton equipment is *engineered* to fit your needs. It is *designed* to improve the practical, day-to-day creativity of your engineers or draftsmen. Its performance has been tested and *proved* in many thousands of installations. Our designers will gladly assist in the planning of your department. No obligation, of course.

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WHILE
THE
METAL'S
HOT**

**TO FORGE
SUPERIOR**

TOUGHNESS

*and high
ultimate
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Here in fierce heat and pressure of the forging process is seen the literal birth of endurance in metal. No other method compares for preserving and improving physical properties. No other method refines metal structure to comparable levels of toughness and fatigue resistance—or provides like opportunity to reinforce strength at points of stress by control of grain flow.

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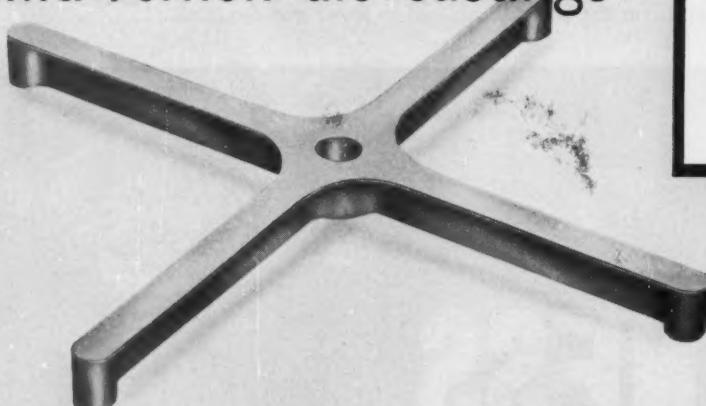
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Circle 274 on Page 19

Steel furniture manufacturer gets these 5 benefits from Mt. Vernon die castings



CASE HISTORIES FROM MT. VERNON FILES

Subject:

Art Steel Company, New York City

In a major switchover, Art Steel Company makes this handsome Steelmaster Desk with aluminum die cast legs. The companion Executive Chair stands on a die cast aluminum base. Formerly it took 8 parts to assemble each island leg of the desk... and 14 parts for the chair base. But switching to die cast parts gave Art Metal Company 5 major benefits:

1. Simpler fabrication since all castings are one-piece integral units. No more multiple section subassembly work.
2. Complete freedom in designing due to the many inherent advantages of the die casting process.
3. Corrosion of legs and bases caused by office cleaning detergents no longer a problem. Aluminum die castings stay bright and attractive.

4. Die castings are delivered polished, drilled and tapped, ready for use. Several assembly steps previously required have been eliminated.
5. Because production of legs and bases has been put into Mt. Vernon, valuable production capacity at Art Steel has been freed for other requirements.

More and more, in a great variety of products, Mt. Vernon Die Castings are replacing complex sheet metal assemblies and costly, crude sand castings, bringing significant production economies to the manufacturer. All the knowledge we have gained on this subject is also available to you... free. Why not discuss your problem with us too. A call to your nearest Mt. Vernon representative will bring you action.



MT. VERNON DIE CASTING CORPORATION STAMFORD, CONNECTICUT



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MARIETTA, N. Y.: Mr. Burt J. Meldrum, Olano Road

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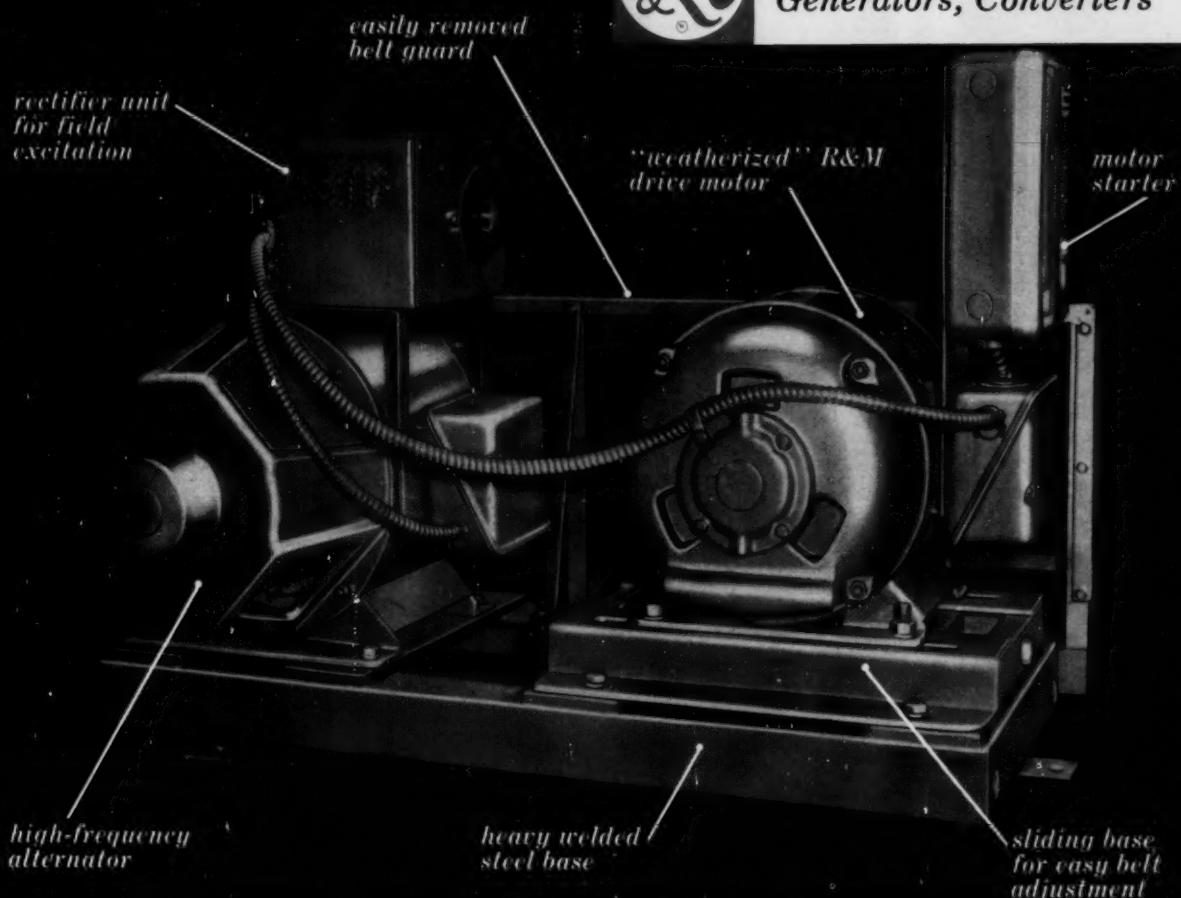
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Compact High Frequency Power Generators

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Circle 276 on Page 19



SOLVE FASTENER PROBLEMS CAUSED BY SHOCK OR VIBRATION... SIMPLIFY ASSEMBLY with Republic NYLOK® Bolts and Nuts

Applications are unlimited for rugged, self-locking Republic NYLOK® Bolts and Nuts. They lock tight—seated or not—to simplify assembly, solve a wide range of design and engineering problems caused by shock or vibration.

Single-unit NYLOK Bolts and Nuts are easy to apply manually or automatically, can be used over and over. NYLOK Nuts are double-chamfered to permit automatic feeds at top production speeds, save time and money.

Check your product for applications where NYLOK's positive holding power can do the job better, save you money. For sizes, prices, and application data on NYLOK Bolts and Nuts, contact your Republic Dealer, or send the coupon.

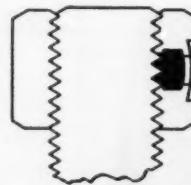


Strong, Modern, Dependable

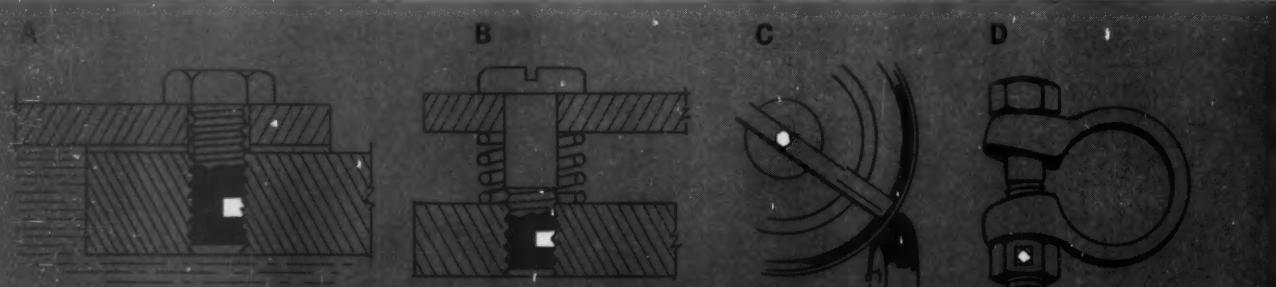
NYLOK'S SUPER-LOCKING SECRET

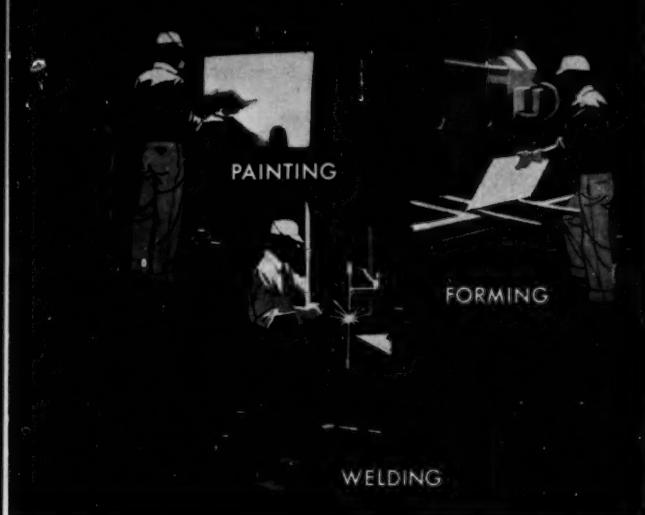
is its nylon plug, firmly staked into one of the faces of the cold forged hex nut, or into the body of the bolt. The plug has a plastic memory—or a natural tendency to recover its original shape and "grow" into opposite mating threads. This forces tight metal-to-metal contact for a vibration-proof lock that can't shake loose.

Circle 277 on Page 19



Typical NYLOK applications: (a) NYLOK Bolt as a fastener-sealer to effectively block fluid escape along thread path; (b) NYLOK Bolt used to solve tension or vibration fastening problems; (c) NYLOK Nut used to secure lawnmower rotor blade under severe vibration conditions; (d) NYLOK Nut employed to lock tight against pressure of a spring-clamp.





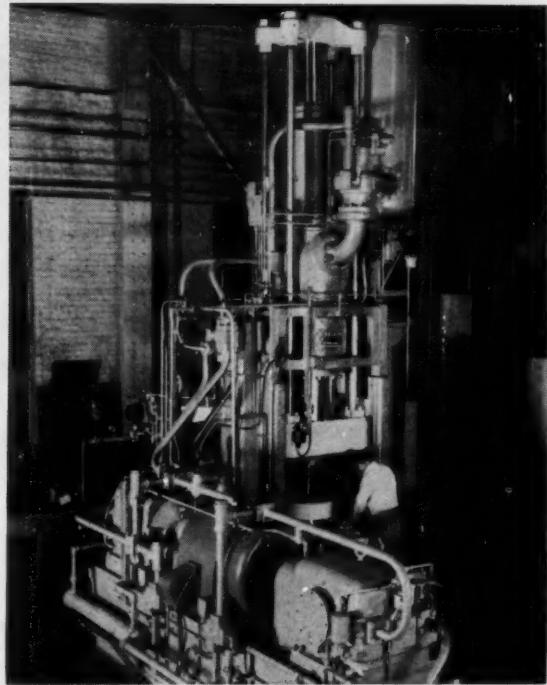
FROM DEVELOPMENT THROUGH FINISHED PRODUCT Republic's Berger Division can help you cut costs on sheet metal fabrication. Contract manufacturing specialists for more than five decades, Berger has a well rounded stock of tools and dies; a complete machine shop; modern, automated production lines for shearing, punching, forming, welding, Bonderizing, painting, and packaging. Berger will handle your complete job or any phase of it. Send the coupon for complete information.

Circle 278 on Page 19

SAVE MONEY ON TOUGH-TO-MAKE PARTS. Elliott Co., Jeannette, Pa., does it by producing rotor buckets for mechanical drive turbines from Republic Stainless Steel Special Sections.

User benefits include: simplified machining, corrosion and abrasion resistance, greater strength and hardness, smooth surfaces that reduce or eliminate finishing operations. Republic Special Sections are available in a wide range of sizes and contours—carbon, alloy, stainless steels, and titanium. Send coupon.

Circle 279 on Page 19



STUBBORN RESISTANCE TO FATIGUE is one important reason builders of machine tools prefer Republic ELECTRUNITE® Hydraulic Fluid Line Tubing. Consistent uniformity of concentricity, temper and weld strength make ELECTRUNITE better able to withstand the vibrations of rapid multiple cycling. Uniformly ductile for easy bending.

Pictured is a 500-ton hydraulic press built by Birdsboro Foundry and Machine Co., Birdsboro, Pa. ELECTRUNITE is used extensively in this unit. Send the coupon for more data on Republic ELECTRUNITE Fluid Line Tubing.

Circle 280 on Page 19



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STST*

*Superior Tool Steel Tubing

ODDS: 1000 TO 1 TO CUT COSTS, IMPROVE PERFORMANCE IN 1001 DIFFERENT APPLICATIONS

Superior tool steel tubing is an excellent material for tools, but equally good for 1001 other applications. Odds are that it will cut costs and improve performance wherever it is used. Type E-52100, an oil hardening grade of high-carbon and chromium alloy steel, has been widely used for such diverse applications as thread guides on hosiery knitting machines, nylon yarn guides, ball bearing races, nozzles for blast cleaning equipment, gear and pinion parts, dental instruments and extrusion mandrels. Type E-1095, a high-carbon steel tubing, is serving

as applicators for jewelers' oilers, leather and paper punches, and surgical instruments.

Perhaps you have an application that can benefit from high strength and hardness, good wear resistance, abrasion resistance, shock resistance, and notch toughness. In that case, consider Superior tool steel tubing before you go any farther. It could give you a better product at a lower cost. Send for Data Memorandum #14, a handy guide to your thinking. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.



Superior Tube
The big name in small tubing

NORRISTOWN, PA.

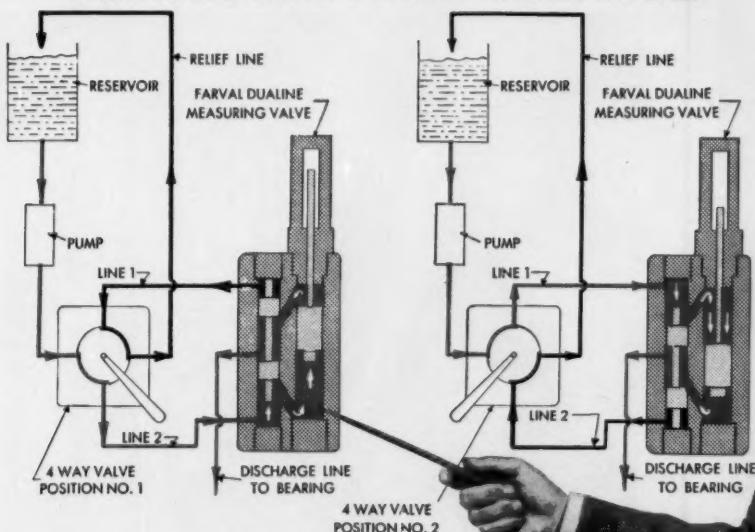
All analyses .010 in. to $\frac{5}{8}$ in. OD—certain analyses in light walls up to $2\frac{1}{2}$ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

FARVAL
—Studies in
Centralized
Lubrication
—
No. 246

*"For positive lubrication of large,
medium and heavy-duty installations
... it's a Farval Dualine System!"*

FARVAL DUALINE SYSTEMS USE SIMPLE HYDRAULIC PRINCIPLES



*With Farval Dualine centralized lubricating systems you get
the following distinct advantages over other type systems . . .*



- (a) Much lower operating pressures with consequently less danger of soap separation on grease systems. Also, less danger of system damage due to high lubricant pressures.
- (b) Large lubricant passages with no pinhole ports, ensures practically full pump pressure for every metering valve. This is one of the reasons why Farval Dualine systems operate on lower pressures — give less sieving and working of lubricants.
- (c) Positive indication at each bearing — does not have to depend on the questionable action of a single indicator at the pump.
- (d) Each metering valve individually adjustable for the requirements of the bearing it serves.
- (e) Independent metering valve operation. Should trouble develop with one valve, the system will continue to operate. Only one bearing (not all the bearings) will require hand lubrication until trouble is corrected.
- (f) True lubricant metering. Quantity of lubricant delivered to one bearing is not dependent on any other valve in the system.
- (g) Much easier to spot and correct trouble.

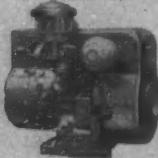
Check with your Farval Representative and see how these versatile systems can improve production operations — reduce costs. Or write for free Bulletin 26-T containing complete engineering information on Farval Dualine systems.

Farval Division
Eaton Manufacturing Company
3287 East 80th Street • Cleveland 4, Ohio



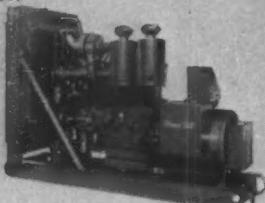
Over 1000 stock models
of Onan Electric Plants!
Expert modification
if you need it

Wherever you need independent electrical power for equipment on the move—or equipment headed for use in remote areas not served by highline power—you need an Onan Plant.



500 WATT ONAN

Over 1000 different models—from 500 to 230,000 watts, with a large variety of starting systems—give you extensive leeway in solving your product's power problem. And every Onan Electric Plant carries the exclusive Onan Performance Certified Tag, assuring you and your customers that every Onan will deliver all the power output promised by its nameplate. Onan's Performance Certification is giving numerous Original Equipment Manufacturers added sales appeal. Let Onan help sell your product.



230,000 WATT ONAN

On Power Shovels and Draglines, Maintenance and Service Trucks, Boats, Mobile Communications Trucks, Sales Demonstration Vans... to name but a few applications... you'll find Onan on the job. You'll find, too, a wide variety of Onan accessories. Various starting systems. Trailers. Various fuel systems. Automatic controls, etc. Each designed for superior performance in your equipment.

ONAN SEPARATE GENERATORS

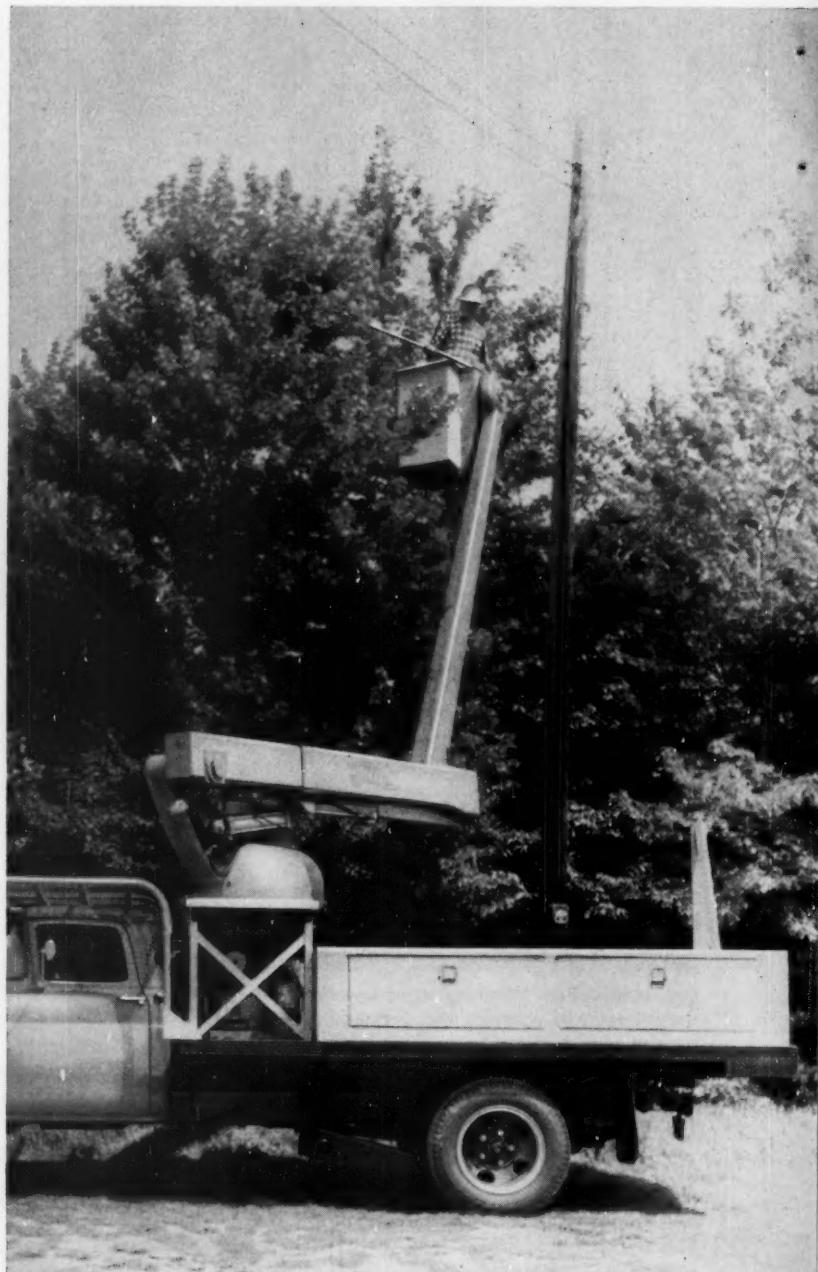
For applications where driving power may be taken from the main engine, Onan supplies separate heavy duty generators.



CALL BOB WESTRUM at Onan. He's an expert in solving power plant problems for Original Equipment Manufacturers. Minneapolis, FEDERAL 2-1155. Or write for complete information on Onan Electric Plants, Generators, other Onan O.E.M. products including Separate Engines and Engine-Driven Compressors.



Electric problems? builder of

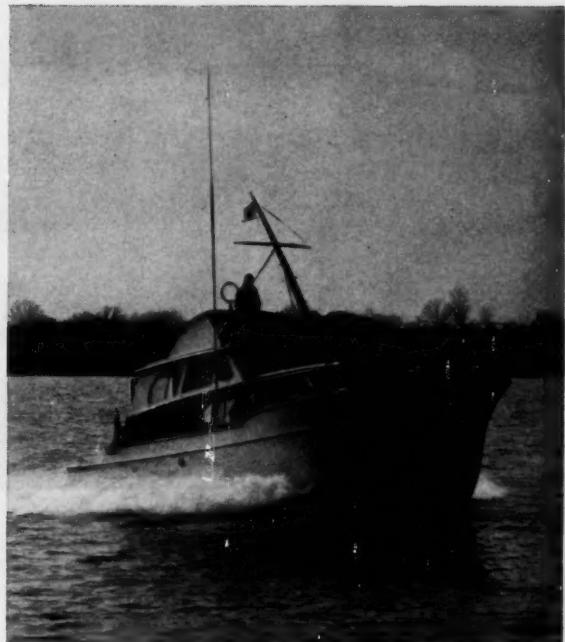


HIGH-FLYING CROW'S NEST is powered by a 3.5 KW Onan Electric Plant... trusted throughout the world as a reliable, independent source of electricity. Do you have a similar electric problem? Let Onan help you solve it.

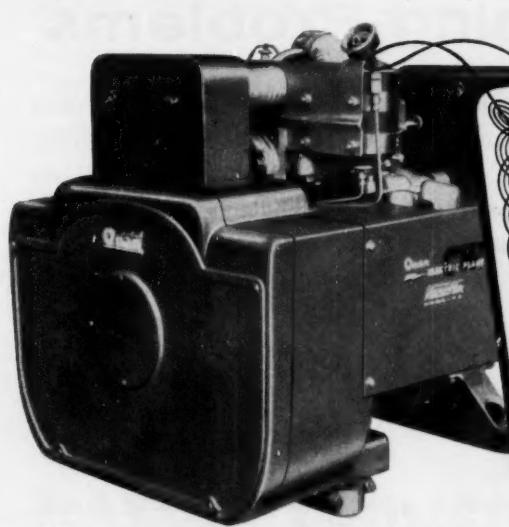
Let Onan, world's leading generator sets, help you!



ICE CREAM STORE ON WHEELS! Wherever it goes, this Onan-electrified van has plenty of power for freezers, lights, fans, even the hot fudge heater. A 10 KW Onan does it all.



ALL THE COMFORTS of modern electrical living aboard crafts like these, thanks to Onan Marine Electric Plants. Put an Onan Plant in your equipment on the move.



POPULAR CW SERIES. This Onan powerhouse—available in 7.5 and 10 KW—features highly efficient Vacu-Flo air cooling. Weighs hundreds of pounds less than comparable water-cooled plants.

PERFORMANCE CERTIFIED

We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.

D. W. ONAN & SONS INC.
Minneapolis 14, Minnesota



WORLD'S LEADING BUILDER
OF
ELECTRIC POWER PLANTS

Onan Division,
Studebaker-Packard Corp.
2721 University Ave., S.E.,
Minneapolis 14, Minn.

Designers think of R/M first for asbestos, rubber,

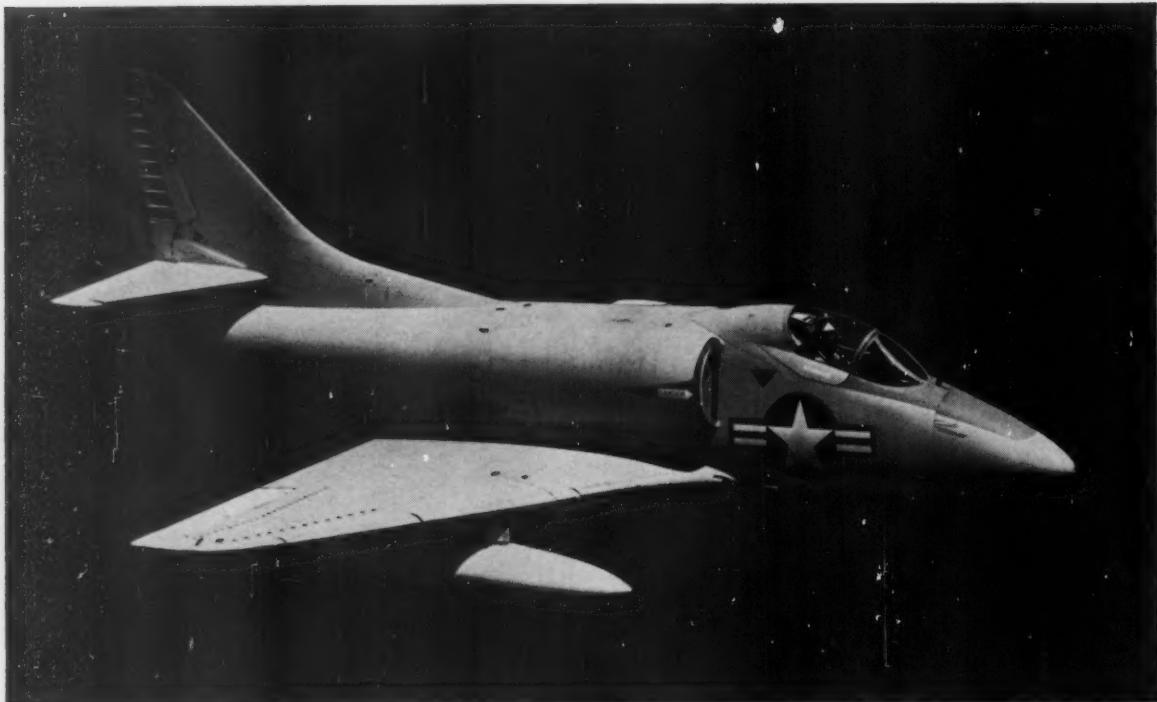


Photo courtesy Douglas Aircraft Company, Inc.

Bonded, rivetless, aluminum-cored structure of the Douglas A4D Skyhawk's rudder section prevents skin-crack failures. Conventional riveted structure could not stand pre-service load and vibration tests. Sonic flight vibration would have caused cracks between rivets on skin.

11 Ways *Ray-BOND* Adhesives Solve Tough Fastening Problems

New bonding and laminating techniques at R/M help solve difficult fastening problems and thereby make possible many of the new products being developed and produced by America's advancing technology.

The advantages of Ray-BOND Adhesives include:

- Rivets can be eliminated • Members too thin to rivet can be joined and fixed • Manufacturing costs are reduced • Life of wearing surfaces is extended • Heat conductivity is improved • Weight reduction is substantial • Load is uniformly distributed over joint area • Bond produces residual elasticity • Complex shapes can be easily fabricated • Electrical non-conductivity and protection against corrosion can be achieved • Methods of application are fast, economical, flexible

Counsel and detailed technical information regarding the selection and application of adhesives are freely available to you from Raybestos-Manhattan. An R/M representative can call on you promptly to discuss your requirements.

ADHESIVES



Get helpful engineering information on selecting, bonding and testing adhesives. Write today for your free copy of Bulletin No. 701. Adhesives Department, Raybestos-Manhattan, Inc., Bridgeport, Conn.

sintered metal, and engineered plastic products



R/M CAPABILITY PRODUCES VALVE STEM PACKING of low volume loss at up to 1150°F

Low volume loss is a basic requirement of high-temperature valve stem packings. Reliable sealing characteristics are assured when valves are packed with R/M No. 325 because total volume loss is *less than 5%*. R/M No. 325 high-temperature valve stem packing is free of the organic materials that make other packings burn out and require much adjustment. Contains AAA grade Inconel-wire-inserted asbestos yarns braided over a plastic core that will not fuse. R/M No. 325 offers an extra dividend in that it contains a corrosion-resistant inhibitor that protects against valve stem pitting after valves are hydrostatically tested and stored.

There are R/M valve stem packings for your every department, each offering superior advantages. Let us know your requirements and depend on us to meet them.

PACKINGS

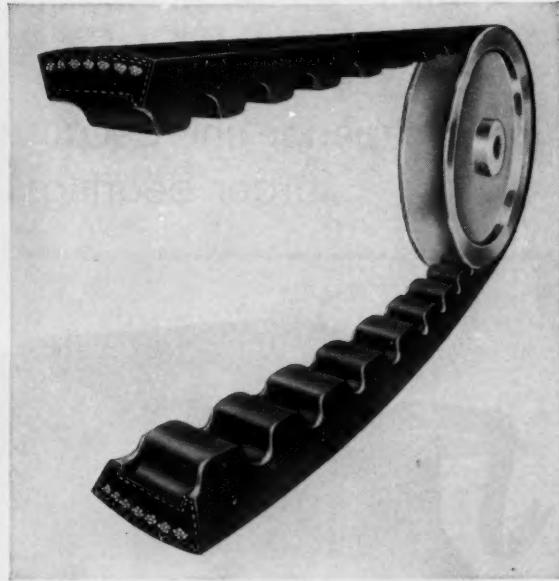


For complete information on R/M Mechanical Packings and Gasket Materials, write for new Catalog P-100. Packing Division, Raybestos-Manhattan, Inc., Passaic, N.J.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Circle 285 on Page 19A



R/M CX MOLDED V-BELT OUTLASTS—AND OUTPERFORMS OTHER BELTS 8 to 1 ...

Use R/M CX Molded V-Belts wherever more flexibility and ruggedness with quieter, cooler vibration-free operation are required.

- Fully Molded—Fully Jacketed
- No Cut Notches—No Exposed Sides
- Holds Shape and Effective Length Without Stretch
- Vibration-Free—No Slap, No Hum, No Buzz
- No Ply Separation—No Flex-Cracking
- Ideal for Small Sheave Diameters, Short Centers, High Speeds

It's the only notched V-belt of its kind made. Let R/M specialists work with you on V-belts, rubber hose, transmission or conveyor belting, molded or extruded parts.

RUBBER



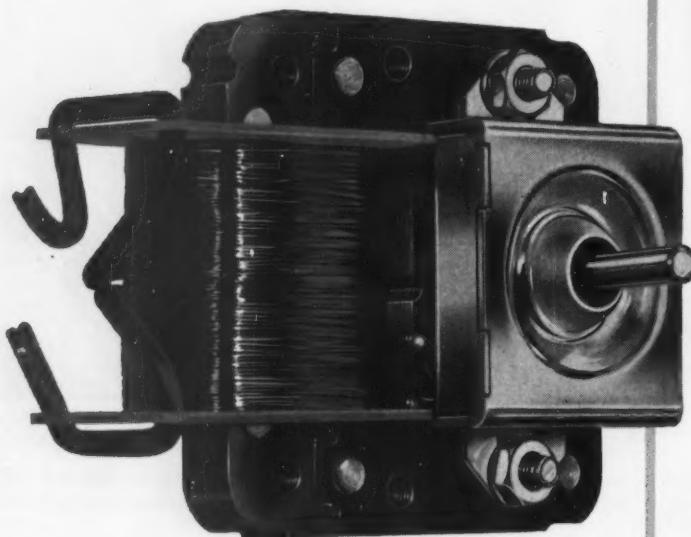
Write today for Bulletin M220 and booklet shown: full details on a wide variety of industrial rubber products. Manhattan Rubber Division, Raybestos-Manhattan, Inc., Passaic, N.J.



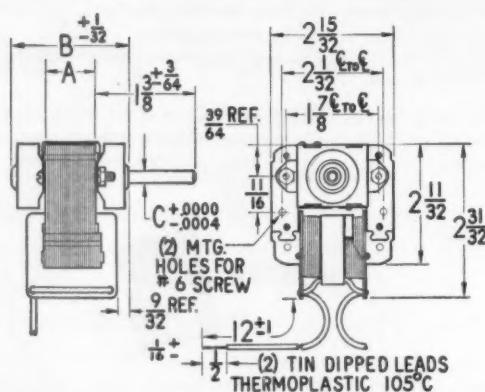
Circle 286 on Page 19A

NEW TYPE EA1 UNIVERSAL SKELETON MOTOR

a superior unit because of quality construction,
larger bearings and greater oil capacity



- Larger bearings and greater oil-felt capacity give longer motor life.
- Grooved bearings insure continuous oil return.
- Larger bearings reduce motor noise.
- Accurate metallurgical control of laminations insure uniform performance.
- Interchangeable mountings.
- Six standardized models, 1/500 to 1/45 HP.
- The correct motor for rotisseries, vending machines, office machines, chart drives, phonographs, slide projectors, heaters, refrigerators, hair dryers, deodorizers, 2" to 8" diameter fan blades, electronic equipment, etc. Write for complete specifications on your requirements.



SPECIFICATIONS

UNIVERSAL TYPE EA1 SKELETON MOTORS 115 VOLT 60 CYCLE

MODEL	HP @ 2,800 RPM	MAXIMUM TORQUE oz. in.	DIMENSIONS		
			A	B	C
EA1A	1/500	1.1	3/8"	1 3/16"	.1817
EA1B	1/350	1.4	1/2"	1 1/16"	.1817
EA1D	1/130	3.3	3/4"	2 1/16"	.1817
EA1E	1/90	4.5	1"	2 1/16"	.1817
EA1G	1/60	6.5	1 1/2"	2 1/16"	.250
EA1J	1/45	7.5	2"	3 1/16"	.250

12" leads on all models

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSO, MICHIGAN, DEPT. 10



57



This mark tells you a product
is made of modern, dependable Steel.

Smooth...inside, outside...and accurate, too!

For a very fundamental reason, more and more Engineers, Designers and Purchasing Agents are specifying USS National Electric Resistance Welded Steel Mechanical Tubing—it saves money.

Dimensional accuracy and closely controlled mechanical properties insure consistency—consistently low machining losses, uniform strength, low fabrication costs and high torsion resistance—and the tubing is smooth inside and outside.

Whether your tubing application requires the dependability for a load-carrying member or the surface smoothness quality for a hydraulic cylinder, USS National Electric Welded Mechanical Tubing must be your first consideration.

USS National Electric Welded Mechanical Steel Tubing is available in a wide range of cold drawn or hot rolled sizes from as small as $\frac{3}{8}$ " x .028" to as large as $5\frac{1}{2}$ " x .250". Your National Tube Distributors throughout the country will gladly show you how tubing can reduce your costs. See your USS National Tube Distributor.

USS and National are registered trademarks

National Tube
Division of
United States Steel



Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

Circle 288 on Page 19

new-lube-free....



...Sterling's variable speed drive never requires lubrication

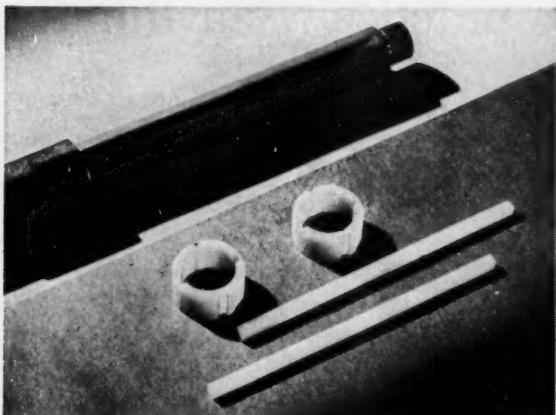
Costs Reduced—One of management's biggest headaches has been the development and maintenance of proper lubrication schedules. As a consequence, lubrication problems have long been the cause of variable speed drive failures, pulley wear, sticky pulleys, shortened belt life, excessive noise, and many other equally costly problems.

High labor costs, coupled with increased maintenance needs, are major management problems.

Lubrication Eliminated—Now, Sterling has eliminated all lubrication maintenance problems. No part of a Sterling variable speed drive needs to be lubricated.

All bearings, sealed and shielded, are factory-lubricated and therefore require no lubrication. Shaft surfaces are impregnated with a special exceptionally tough and wear-resistant material which eliminates need for lubrication. The non-metallic bushings are also fabricated from a special material that is equally wear-resistant.

Special Load-Bearing Surfaces—At no time do these surfaces require any attention. Even the keys are fabricated from a tough elastic material and will not wear out.



Shaft surfaces are extremely tough; material provides unusual chemical resistance and anti-frictional properties that make an excellent load-bearing material operating under extremely low or high temperatures. Keys and bushings are fabricated from a material proven to have outstanding abrasion resistance; holds up indefinitely under frictional conditions, thus eliminating need for lubrication.

Fret corrosion, long a problem with metallic load-bearing surfaces, is completely eliminated since non-metallic surfaces now carry the load. Sticky pulleys, frequently the result of improper lubrication, are no longer a problem.

Sterling's new "Lube-Free" variable speed drive can be installed in any location, no matter how inaccessible, since lubrication maintenance is no longer needed.

Other Benefits—Costs are reduced, money saved, when lubrication maintenance is no longer necessary. Belt life is lengthened; pulley wear is eliminated. Bearing life may also be lengthened by the elimination of worn pulleys—often the cause of vibration and bearing wear.

All other Sterling variable speed advantages are present in this new "Lube-Free" drive: wide range of speeds, heavy duty cast iron case, finger-tip speed control, etc.

Information Available—Complete application and product information is available by writing Dept. B-7, Sterling Electric Motors, Inc., 5401 Telegraph Road, Los Angeles 22, California—or by contacting the Sterling field engineer in your area.



This V & O Notching Press is powered by a new Sterling "Lube-Free" variable speed drive. It will never need lubrication. Similar units have been installed in the food processing industry. The elimination of lubrication is particularly important in the food processing industry where variable speed drives have such wide application, and where oil and grease create sanitation problems.



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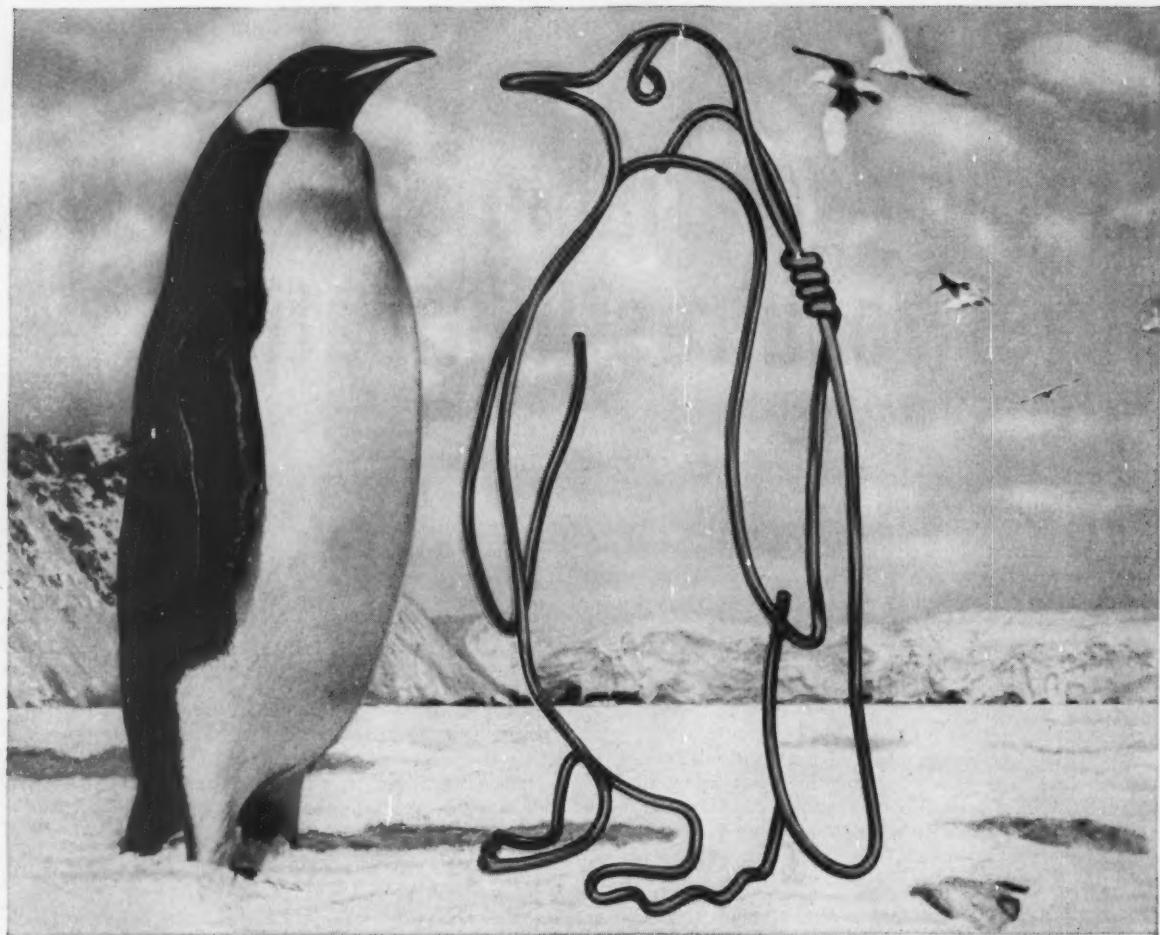
April 13, 1961

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Sterling Electric Motors, Inc.

5401 TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA,
A Subsidiary of HATHAWAY INSTRUMENTS, INC.

125

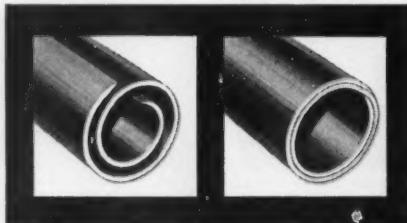


Bundy can mass-fabricate practically anything

You design it. We'll find a way to mass-fabricate it . . . by the millions if needed. Our engineers will work with you at any time. They can often help you find cost-saving solutions to difficult tubing problems by using Bundyweld® steel tubing. For example, Bundyweld can be bent to close tolerances, flanged, upset, expanded, swaged, beaded or special formed. Standard wall diam-

eter and O.D. are held to +.002" to -.003". Bundyweld meets ASTM 254; Govt. Spec. MIL-T-3520, Type III. For help, call or write: Bundy Tubing Company, Detroit 14, Michigan.

* * *



Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight, uniformly smooth and easily fabricated . . . has remarkably high bursting and fatigue strengths. Sizes up to $\frac{5}{8}$ " O.D.

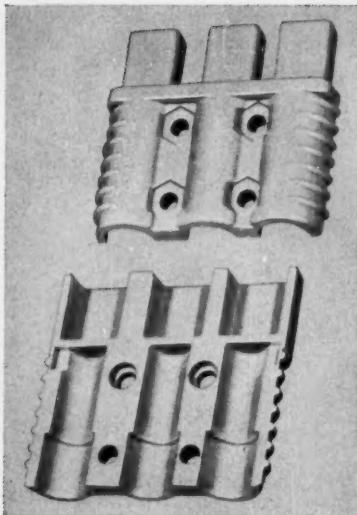
BUNDY® TUBING COMPANY

DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

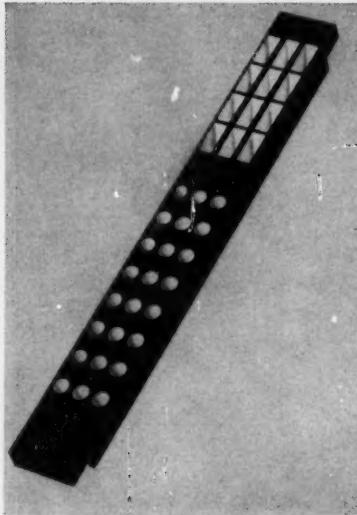
WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, ITALY, JAPAN.

G-E LEXAN® POLYCARBONATE RESIN

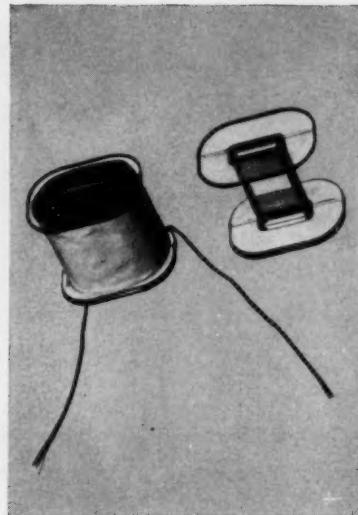
TOUGHEST OF PLASTICS!



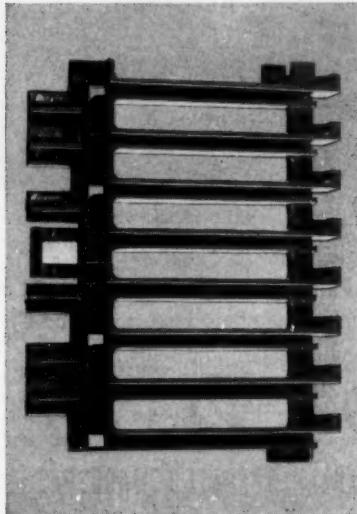
STRENGTH LEXAN resin has an impact strength of more than 12 foot-pounds per inch of notch — higher than any other plastic! This toughness, plus heat resistance and good electrical properties, make LEXAN resin an outstanding choice for 3-pole connectors used in rugged service on electric trucks.



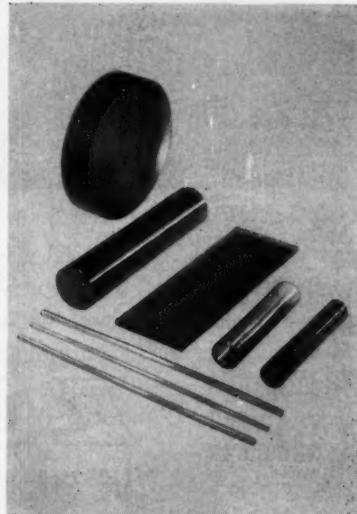
HEAT STABILITY Lampholder terminal block is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. LEXAN has a heat distortion point as high as 290°F. Also keeps high strength in sub-zero cold.



ELECTRICAL PROPERTIES A good dielectric, LEXAN resin is non-corrosive even when used with very fine Class F magnet wire. Coil forms must not distort at temperatures above 200°F under stresses caused by tightly wound wire. LEXAN resin provides high heat distortion temperatures under load.



DIMENSIONAL STABILITY Card Guide for business machines is molded to close tolerances . . . must undergo minimum change in dimensions during service. Parts show excellent dimensional stability under moist and high temperature conditions. LEXAN resin meets self-extinguishing requirement.



TRANSPARENCY Stock shapes and film of LEXAN polycarbonate resin have excellent transparency. Bar stock is easily machined; film can be thermoformed, heat-sealed and solvent-sealed. Combination of clarity, toughness and malleability gives LEXAN resin the design capabilities of a transparent metal.

LEXAN OPENS UP NEW OPPORTUNITIES...

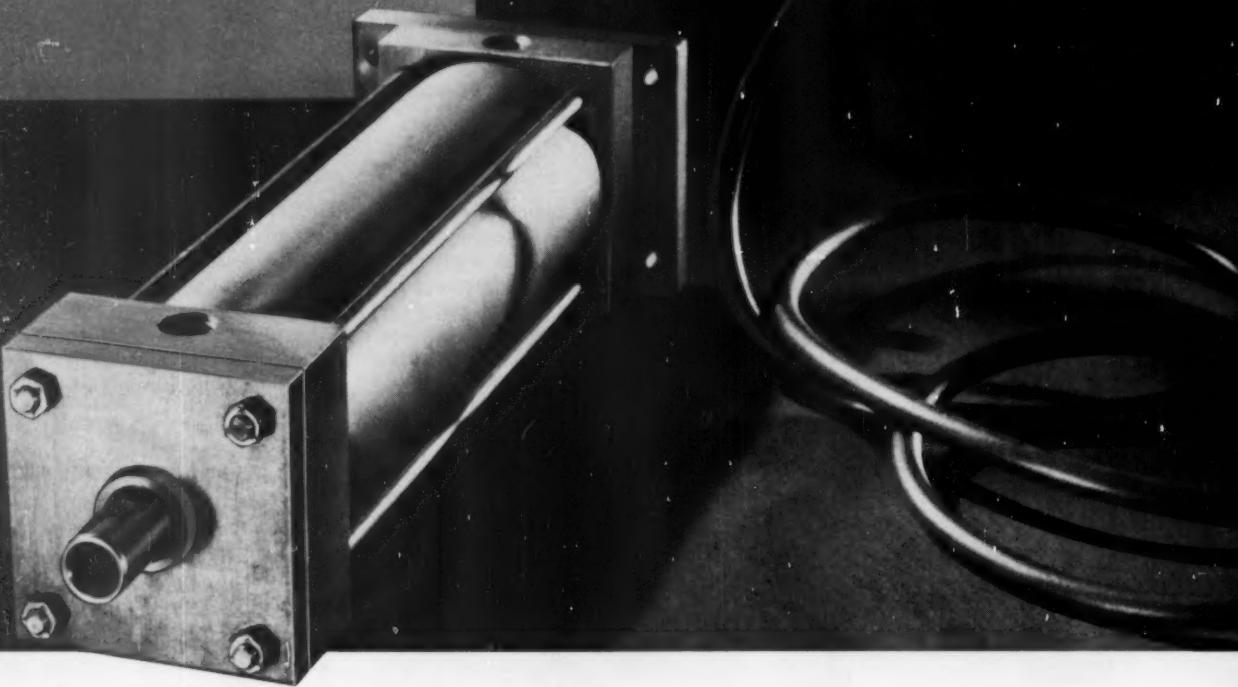
Even before LEXAN entered large-scale production, manufacturers, impressed by its exceptional properties, developed and field tested over 300 applications. G.E. participated in these developments. With the opening of new G-E facilities capable of producing millions of pounds of LEXAN per year, the price of this versatile thermoplastic has dropped dramatically — over 40% in a single year. This fact alone has brought many new products within the range of feasibility. Can you afford to overlook the opportunities presented by LEXAN? Send for details on price, properties, applications and G-E's technical assistance program today! General Electric, Chemical Materials Department, Section MD-41, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

**connect
an air line
to this cylinder**

**AND MAKE
YOUR DESIGN JOB
A LOT EASIER**



The cylinder simplifies your design work substantially, because it produces virtually any kind of motion—and does so *without the use of complex mechanical contrivances!*

It provides constant, even pressure at all times, and this pressure can be varied with a simple adjustment. Its compact size, along with the use of a flexible line, makes it easily adaptable to

special machine design.

If you would like more information about cylinders, or the many other Logan products, just fill in and mail the coupon below.

LOGAN
AIR AND HYDRAULIC OPERATED MACHINES

Check the items you want, fill in your name and address, tear out and mail to:

Logansport Machine Co., Inc. • 710 Center Avenue, Logansport, Indiana

<input type="checkbox"/> 100-1 AIR CYLINDERS	<input type="checkbox"/> 200-1 HYD. POWER UNITS
<input type="checkbox"/> 100-2 MILL-TYPE AIR CYLS.	<input type="checkbox"/> 200-2 ROTOCAST HYD. CYLS.
<input type="checkbox"/> 100-3 AIR-DRAULIC CYLS.	<input type="checkbox"/> 200-3 750 SERIES HYD. CYLS.
<input type="checkbox"/> 100-4 AIR VALVES	<input type="checkbox"/> 200-4 and 200-7 HYD. VALVES
<input type="checkbox"/> 100-5 LOGANSQUARE CYLS.	<input type="checkbox"/> 200-6 SUPER-MATIC CYLS.
<input type="checkbox"/> 100-6 ULTRAMATION CYLS.	<input type="checkbox"/> ABC BOOKLET
<input type="checkbox"/> 100-7 SUB-PLATE AIR VALVE	<input type="checkbox"/> CIRCUIT RIDER
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TITLE.....

COMPANY.....

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BENDIX ELECTROMAGNETIC TOOTH CLUTCH

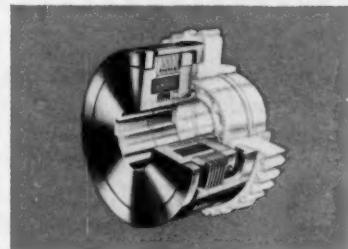
Where space is a problem, design engineers can give their products a competitive advantage by specifying the Bendix® Elmag tooth clutch. It transmits the same torque in a smaller size "package" than other clutches, and is controlled by remote electrical switches or relays.

Thus, the engineer can design for the same torque in less space, or for more torque in the same space. Simple, bolt-on design, unhampered by cumbersome linkages and disengagement mechanisms of mechanical clutches, virtually eliminates design problems in mounting the clutch.

The clutch can be engaged at relative speed, disengaged at any RPM under full load. Once disengaged, there is absolutely no idle torque—no connection

between driving and driven members. The Elmag tooth clutch performs in either wet or dry applications. Most models available from stock in torque capacities of 40 to 4,000 ft.-lbs. Diameters, 3.000" to 9.055".

BENDIX ELMAG MULTIPLE DISC CLUTCH—Ideal for step-by-step acceleration of large masses. Disc stack is magnetically isolated. Wet or dry operation. Slip ring or stationary field design. Torque capacities: 10 to 16,000 ft.-lbs. Diameters: 3.93" to 22.04".



For full details, write

Bendix-Elmira

Eclipse Machine Division
Elmira, New York



Visit Bendix Booth No. 1149
DESIGN ENGINEERING SHOW
Detroit, May 22-25



Champion Upset forgings Cut Valve Manufacturer's Finished Cost 30%!

At first glance this valve part looks like a typical screw machine product. But see that big wad of metal on the end of the stem? . . . It's the tip-off that you can save money with an upset forging.

Any automatic screw machine part must start with stock of the largest part diameter and be worked down . . . with considerable waste.

In upset forging, you generally start with the smallest diameter and increase the part size to the largest diameter . . . with almost no waste. Forging

also increases strength, by directioning grain flow in the metal.

If you're using similar parts, check with Champion and see how much you too can save by starting with an upset forging.



**THE CHAMPION
RIVET COMPANY**
T. P. Champion, President
CLEVELAND 5, OHIO • EAST CHICAGO, INDIANA



When it's a vital part, better make it

SILICOLOGY

Studies in Silicones

HOW THESE TIME-TESTED MATERIALS
CAN WORK FOR YOU

For Shear Reliability— Design with Silicone Fluids

Some of the most astonishing things that hydraulic systems are doing today are being done by and because of silicone fluids. In automotive applications, for one, they're the lifeblood of certain long-lasting hydraulic transmissions, power steering, speed-and-temperature-regulated fans. In aviation and other fields, you'll find them in sensitive gyroscopes, damping devices, liquid springs, valve lifters.

MANY USEFUL PROPERTIES

Of course, designing such systems requires knowledge of silicone fluid behavior. Knowledge of viscosity-temperature properties, oxidative and thermal stability, lubricity, thermal expansion, effect on rubber seals of all kinds, compressibility, and apparent viscosity vs. shear rate.

This last is particularly important. And the well-defined shear-viscosity curve of UNION CARBIDE Silicone Fluids, combined with their unique temperature stability (remember that shearing raises fluid temperature), makes them among the most dependable of hydraulic fluids.

You may have heard or discovered for yourself that silicone fluids make elastomeric seals shrink, and may even have dismissed them from your consideration, much as you would like to take advantage of their other properties. Then here is news:

EFFECT ON RUBBER SEALS

UNION CARBIDE has conducted extensive studies of the effect of silicones on various elastomers, and has shown how this problem can be easily met by the use of proper additives in the fluids. In the accompanying table you can see, for example, how "Plexol" 201 additive (Rohm & Haas) in silicones affects the per cent volume change of Neoprene W rubber. Similar data covers per cent weight change, compression set, hardness, etc. Moreover, these data are available on many other natural and synthetic rubber compounds.

How can you get them? They're available now, along with much other important information including more detailed shear-viscosity curves. Just mail the coupon for our latest "Design File" on

UNION CARBIDE Silicone Fluids for Mechanical Applications. It provides in one handy package just about everything you need to know about silicone fluids for your projects.

Effect of Silicone Oil on Neoprene W Rubber

Immersion Fluid	% Volume Change	
	7 days 70°C.	4 days 100°C.
10° L-45	-0.51	-0.15
100° L-45	-0.47	-0.55
1000° L-45	-0.58	-0.69
1000° L-45 + 2.5% "Plexol" 201	4.47	3.75
1000° L-45 + 7.5% "Plexol" 201	17.02	18.60
L-527	8.34	10.66
Water	9.73	15.75

*centistokes



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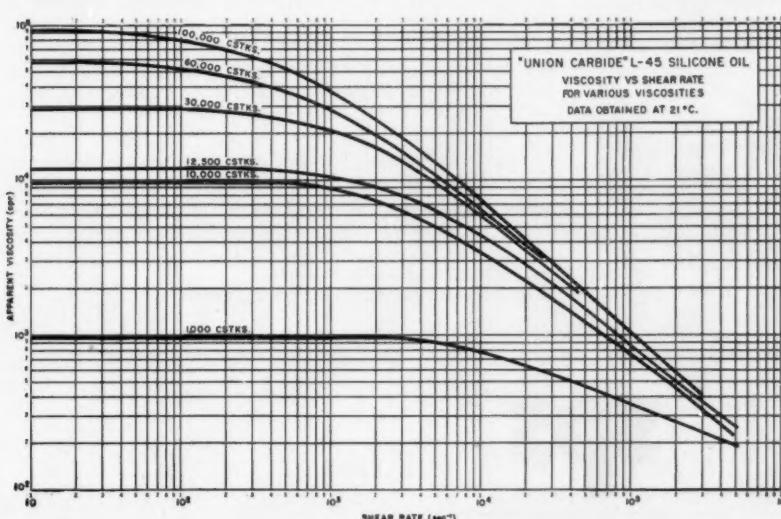
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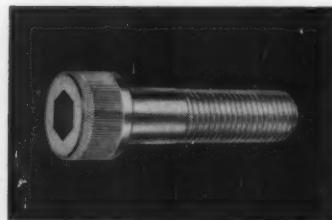
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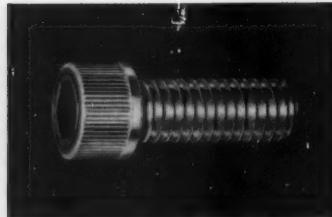
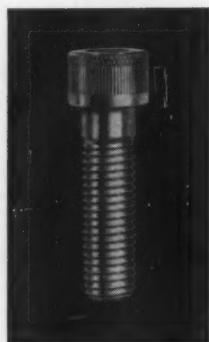
Here's what SPS—and only SPS—now offers you in standard socket head cap screws

UNBRAKO pHd Hi-Life, today's only all-new socket screw. Increased bearing area, radiused thread root give up to 2½ times as much holding power, twice the fatigue strength of ordinary screws.



K 16 socket heads give you a bonus of 300% more fatigue life than regular socket screws; replace costly specials, provide design insurance in high fatigue applications.

Stainless UNBRAKOS meet your needs for corrosion-resistant fastening through a temperature range from -300° to 800° F. Other design considerations: low magnetic permeability; good appearance.



UNBRAKO KS 812 stainless socket screws offer 125,000 psi tensile—certified; help you increase strength of stainless assemblies without paying the price of specials. Identified by groove around socket.

Lately you have been reading about new developments in the design and performance of UNBRAKO socket head cap screws. For your reference, here is the complete story in one package:

UNBRAKO pHd* with Hi-Life Thread

The advanced tension fastener for the '60s. New pHd head with increased bearing area gives you up to 2½ times as much holding power, safeguards preload, defies loosening under vibration. Radiused root of new SPS Hi-Life thread form drastically reduces stress concentrations at point where 85% of screw failures occur. Result: Twice the fatigue life. Forged heads, rolled threads preserve grain flow, add further strength and fatigue resistance. Available with Nylok† self-locking feature if desired. Sizes #0 to 1½ in. in alloy steel . . . full range of plating and other finishes. Tensile strength: 160-200,000 psi.

Stainless UNBRAKO Socket Screws

Available in a variety of corrosion-resistant alloys . . . and with Nylok. Standard processing includes passivation surface treatment, which forms a protective film and removes contaminants. Silver plating and/or molybdenum disulfide can be added as a lubricant to prevent galling and reduce the thread friction sometimes encountered at elevated temperatures. Sizes #0 to $\frac{1}{2}$ in. with forged pHd head and fully formed Hi-Life thread.

NEW HIGH-PERFORMANCE UNBRAKO K SERIES

UNBRAKO K 16—Endurance fasteners replace specials in high fatigue service. They give you *twice* the fatigue life of regular UNBRAKOS; *four* times that of ordinary socket heads—in a standard fastener, reasonably priced. Threads rolled, fillet under head cold worked—both after heat treat. Shank precision ground to insure no decarburization. Sizes #8 to $\frac{1}{2}$ in. in 8740 A.Q. steel. pHd head, Hi-Life thread.

UNBRAKO KS 812—A stainless socket head cap offering a guaranteed tensile strength of 125,000 psi *minimum*. Yet this precision forged, burr-free fastener is a standard, available in quantity off the shelf. Made of high-grade austenitic stainless, hardened through cold working. Has pHd head for greater holding power; SPS Hi-Life thread for increased fatigue resistance. Magnetic permeability under 1.2. Serviceable from -300° to 800° F. Sizes #8 through $\frac{3}{8}$ in.

Standard UNBRAKO socket head cap screws are available from stock through your industrial distributor. See him for more information or write Standard Pressed Steel Co. INDUSTRIAL FASTENER Division, SPS, JENKINTOWN 18, PENNSYLVANIA.

*proper Head design (1960 Series)

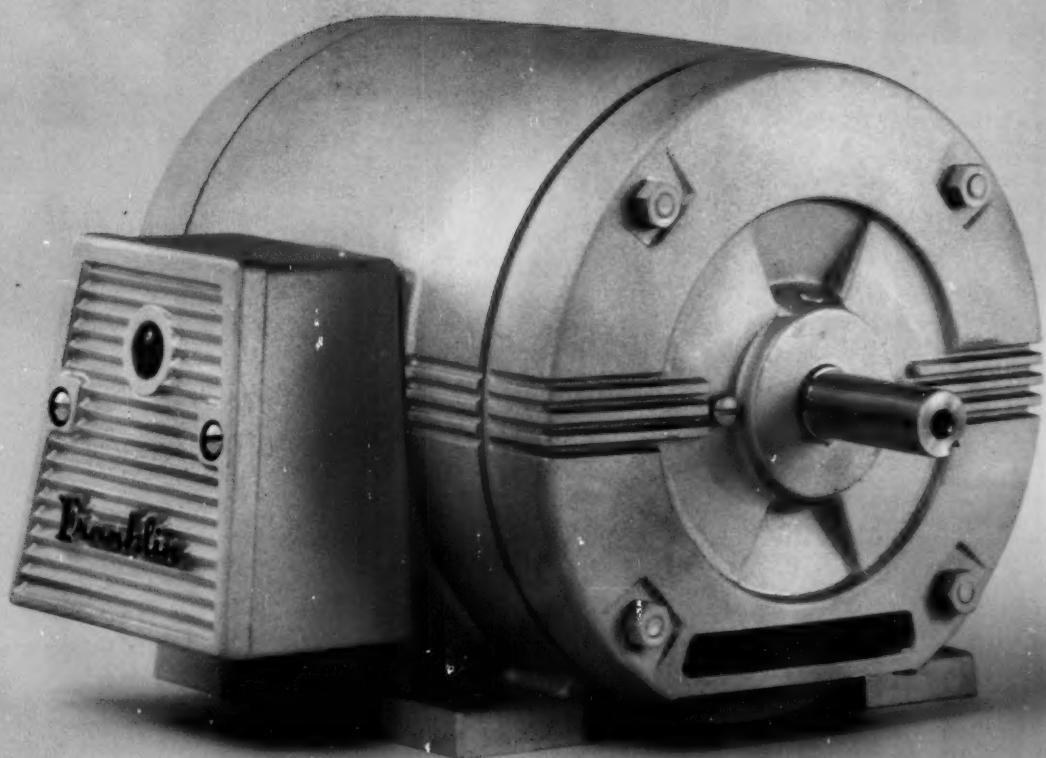
†T.M. Reg. U.S. Pat. Off., The Nylok Corporation

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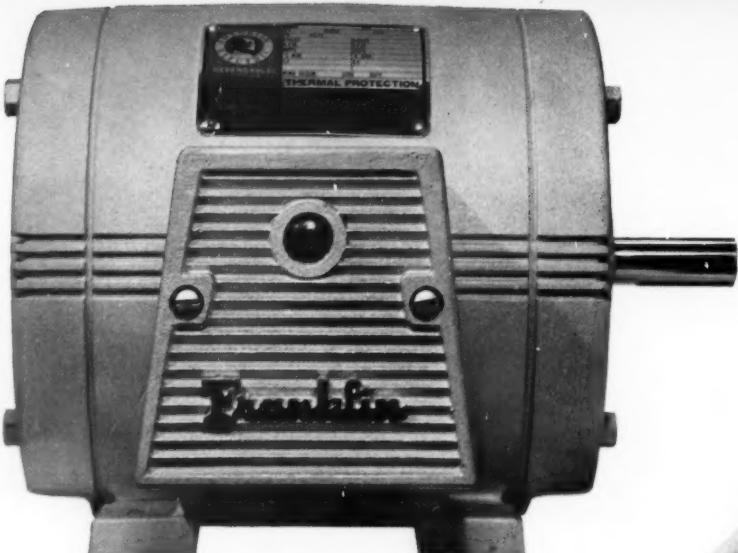
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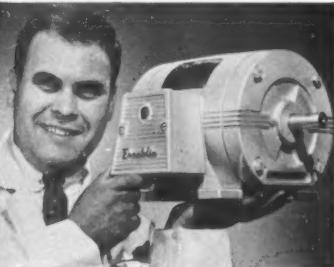
YOU CAN'T SEE
THE OVERLOAD
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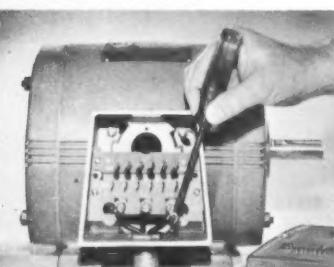
BUT IT'S

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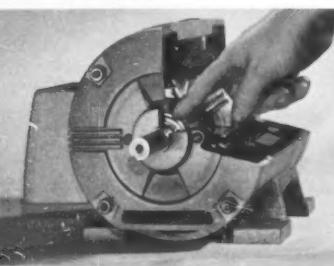
Tough yet lightweight aluminum means lower shipping costs, easier assembly line handling, lower production costs.



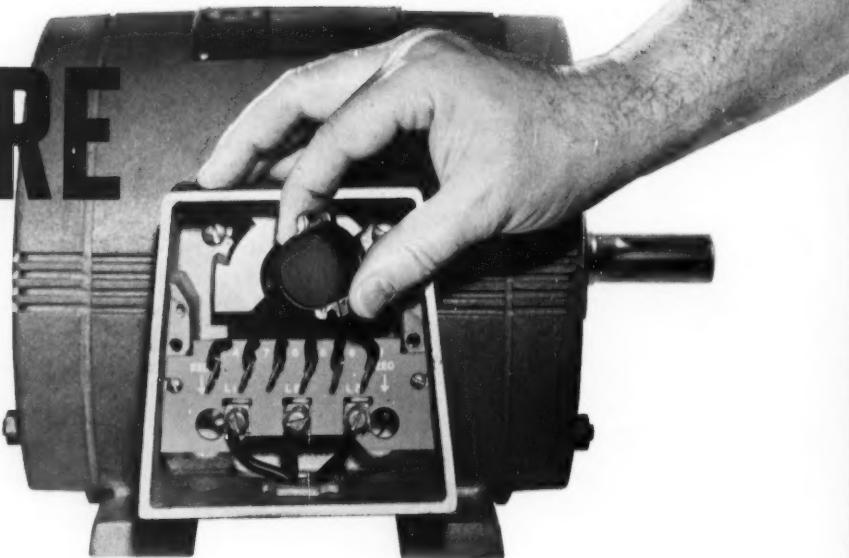
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Inside the Franklin conduit box is a common sense idea that every engineer will appreciate. This is the *only* polyphase motor with built-in space for protector devices. Because this one built-in device protects against *all* motor burnout possibilities, even under locked rotor conditions, this new motor can be completely protected at far lower cost than ordinary motors.

The protector comes pre-installed, in exactly the right size to protect the motor under the most adverse conditions. Saves you time *and* money. Another point. The motor's appearance stays streamlined, because protectors stay where they belong—inside. Write for a free color brochure on the new Franklin integral motor.

Franklin® Electric Co., Inc.



BLUFFTON, INDIANA

DESIGN

April 13, 1961



Leaders or Followers?

LONG-RANGE planning is a recognized "must" for any business enterprise that hopes to survive. But how do you plan long range for people with short memories and changeable tastes?

For instance the compact cars produced by the major manufacturers were more the result of crash programs than of long-range planning. Market studies by long-range planners gave no strong hint of the actual size of the demand for such cars. A quick turnaround by the public, triggered by an influx of foreign cars, changed the market picture almost overnight.

Perhaps the key to successful long-range planning lies in the philosophy of Edwin H. Land. According to *Time*, new products at Polaroid don't come as the result of market research or questionnaires

to customers. Land's company relies rather on insight into the deep needs that people don't know they possess.

Certainly the expressed needs of customers must enter into long-range planning. But research of this kind is not the stuff on which leadership is built.

Needed most is the imagination to see, in a new discovery or idea, the potentials of development into new products or services that the public will demand as soon as it learns about them.

Therein lies the difference between true leadership and the "followership" of the ear-to-the-ground pulse takers.

Colin Campbell
EDITOR

1961·1962·1963·1964·1965 Long Range

1961·1962·1963 Intermediate Range

1961 Short Range

The three phases of

MANAGERIAL

PLANNING is becoming increasingly important in effective engineering management. It is not enough for today's manager simply to solve problems as they arise—he must also anticipate and innovate.

The engineering manager has a responsibility to plan the work of his organization and share in the planning for profitable operation of the company as a whole. Engineering management calls for a man with far greater breadth than was necessary only ten years ago.

What Is Planning?

Planning is the formulation of methods to guide the tactics and strategy of an organization. The engineering manager plans by:

1. Establishing objectives.
2. Developing policies.
3. Formulating schedules of necessary activities and resources.
4. Communicating objectives, policies, and schedules.
5. Developing standards and measurements.

Planning may be broken down into three distinct categories: Long-range, intermediate-range, and short-range planning. The time-span covered by each type may vary according to product, company, and

PLANNING

The popular conception of a manager as a supervisor and decision-maker is not entirely accurate. Being able to solve problems isn't enough. The effective manager must also learn to anticipate problems. He must project into the future and formulate plans to ensure the continued effectiveness of his engineering organization.

What planning methods can be used? How far into the future should planning be carried? How often should new plans be made, or old plans reviewed? Here are some answers to these vital questions.

policy. But in general, long-range planning looks ahead three years or more, intermediate-range planning covers a period of from one to three years in the future, and short-range planning covers current objectives, the current fiscal or calendar year, or the immediate future. A typical outline of plans is shown in Fig. 1.

Short-range, or tactical, planning is concerned essentially with current operations of the engineering organization. It consists of the adaptation of long-range plans to immediate conditions. This includes alternative modes of action to meet unexpected events.

Long-range planning, or strategy, is the master plan. It is not, as has been suggested, a master plan designed by geniuses for execution by idiots. The strategy must present a set of rules which allows freedom of expression to the professional engineer. Unfortunately, piecemeal planning has often led engineers to consider organizational strategy as a master plan conceived by idiots for execution by geniuses.

Long-Range Planning

In long-range planning, over-all business strategy must take precedence over the plans of component

organizations which are concerned with running the company. Responsibility for long-range planning rests with the chief executive, but the engineering manager and the heads of other organizational components must participate in such planning.

Since the engineering and marketing groups are most aware of present and future market requirements, they must lead the way in long-range planning. The engineering manager can predict future technological advances and the possibility of turning advanced ideas into marketable products. When the marketing group anticipates future needs, the engineering manager can estimate the time and cost of developing products to fill these needs. This creative aspect of long-range planning is required for setting objectives.

Objectives are developed by the entire long-range planning group. It is, of course, difficult to set up objectives without knowing the company's current situation. For this reason, the planning group must evaluate products, services, market position, and engineering and manufacturing capabilities to identify strong points which can be built upon, or weak points which must be recognized in realistic planning.

Plans should take account of external factors such as social and legal environments, characteristics of

	Assigned to	Date Assigned	Date to be Completed
Technical Plans			
Task 47 Design new locking mechanism.			
Goal A Obtain alternate conceptual designs.			
B Complete technical and cost evaluation.			
C Complete detailed designs.			
Task 48 Make recommendations for new projects.			
Task 49 Test completed engine #10071 before shipment.			
Administrative Plans			
Task 11 Make annual review of engineers in mechanical design system.			
Goal A Evaluate engineers and write appraisals.			
B Make salary recommendations.			
C Discuss reviews with engineers after salary approvals are complete.			
Task 12 Make annual review of engineers in electrical design section.			
Task 13 Make annual review of engineers in development test section.			

Fig. 1—Typical planning outline. Plans are broken down into major categories, then subdivided into individual tasks.

buyers and sellers, and attributes of substitutes and complements of products currently in production. They should also evaluate future business conditions (including competitive actions) to predict the future state of technology and to try to discover and explore new markets.

The final step in establishing objectives is to develop and evaluate alternative plans of action. The engineering manager plays a large part in this activity. He must estimate specifications, cost, and timing of products evolved from concepts not yet developed. Since engineering development usually proceeds at an exponential rate, his task may become quite complex.

If a firm is engaged primarily in engineering large projects lasting over a long period of time (2 to 5 years), the engineering manager must phase in any new projects so that available engineering facilities and manpower will be fully utilized. Fig. 2 illustrates how new-project planning may be laid out.

On the other hand, the engineering manager of a firm which depends on the sale of mass-produced products, or on any product line requiring continuing development, has a somewhat different viewpoint. In planning new products, or innovations to existing products, he must be sure that his plans are in line with the company's long-range objectives. A potential product may be represented by an estimated life cycle such as the one shown in Fig. 3.

Even if the products to be ready for marketing

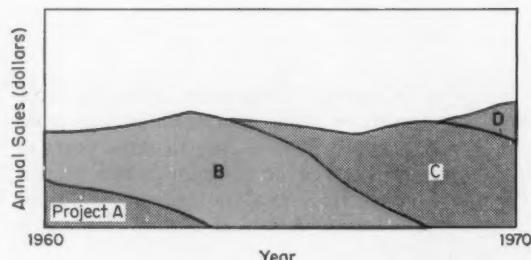


Fig. 2—Long-range phasing of engineering projects. The phasing is planned so that annual sales are at a reasonably constant level.

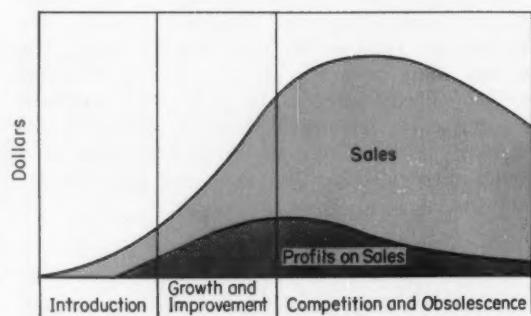


Fig. 3—Life-cycle of a new product.

in five or more years cannot be specified immediately, they must be kept in mind in long-range planning. New-product profits must be phased to keep pace with the rising profit trend, Fig. 4.

The marketing, manufacturing, and finance managers can provide estimates of the profits on the units sold over the life of a product. These profits, however, may be more than wiped out if the engineering manager fails to forecast development costs accurately. In fact, high development costs may play a large part in screening out certain products. Yet the engineering manager must recognize that future technological developments by various outside agencies may put at his disposal solutions to problems which would be costly for his own organization to investigate.

One way to make the most of available engineering personnel is to adopt a composite long-range plan. Engineers are asked to submit a report of goals to be achieved, and ideas to be investigated over the next five years. Each manager then integrates these ideas into a unified program for his group. Individual ideas are also listed for easy reference at any review level. The plans at each level of engineering management become broader in scope until finally the manager of the entire engineering organization receives a set of plans based upon maximum utilization of technical competence of both specialists and managers. The engineering manager then evaluates, modifies, and adds to the plan in the light of his knowledge of business objectives.

Intermediate-Range Planning

Intermediate-range planning is the process of giving definite form to the more general long-range

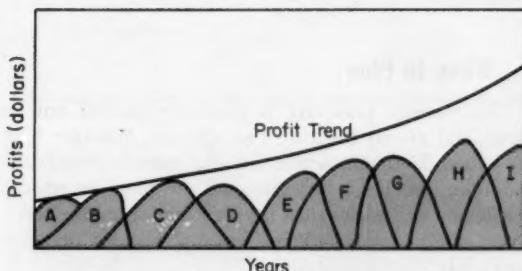


Fig. 4—New-product phasing. Plans are arranged so that dollar profits follow the profit trend of business in general.

plans. It is perhaps the most important task in which the manager of engineering shares. This type of planning is easier to evaluate than long-range planning, since it is more definite in nature and more immediate in showing a payoff. A corporate official—usually the president or general manager—bears the greatest responsibility in long-range planning, whereas the intermediate plans of the engineering organization are clear-cut basic responsibilities of the engineering manager.

Just as in any type of planning, the first step in intermediate-range planning is to establish objectives. These objectives should be consistent with long-range plans with regard to product lines, expansion, stability, or contraction. Objectives may also vary with the type of company and the company's products. The engineering organization may be concerned with:

1. Developing improvements on mass-produced products or ideas for new products.
2. Technological development of complex systems and equipment already in existence.
3. Research and development to produce a completely new system or product to fulfill a customer's requirements.

The engineering manager should try to achieve such objectives while meeting specifications for time, technical performance, and cost.

In planning his major goals for the next three years, the engineering manager should have his engineers compile a list of every significant step which can be clearly defined. These steps include not only the major milestones but also some of the tasks and subtasks.

The engineering manager should use his judgment and previous experience in selecting which tasks are to be done by vendors and which are to be done by his own organization. There are two guiding rules: Don't waste money on things which others are doing or will do for nothing, and make use of subcontractors and consultants for peak loads so that your organization does not suffer through excessive dips and peaks in the workload. Lowest costs can best be achieved by keeping the workload below peak capacity, but at a high enough level to challenge the capabilities of the group.

Vendors are continually seeking to improve their components, and have specialists whose careers have been devoted to one small technological area. These people welcome problems and suggestions from potential customers. It would not make sense for en-

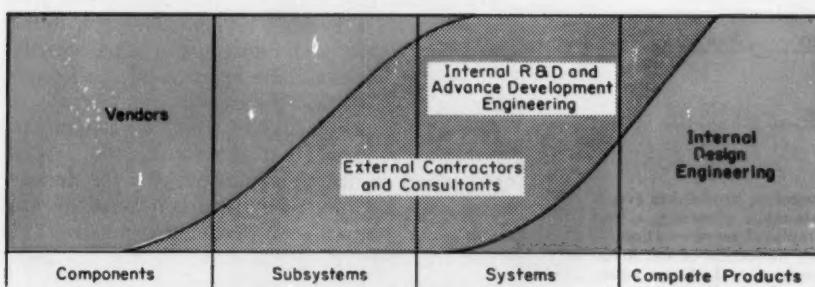


Fig. 5—Assignment of responsibilities during development of a new product. Method provides maximum return from engineering resources.

gineering organizations making products with thousands of components to attempt to duplicate the work of vendors in component development. Fig. 6 shows how duties may be apportioned in systems design work.

Whether an organization is concerned with product innovation or complex system design, the manager of engineering should be familiar with the available tools that can help him in making decisions. PERT (Program Evaluation Review Technique) is an example of such a tool. It is a logical system for connecting production events by time-links to determine the minimum time in which such a network of events may be accomplished. Fig. 6 illustrates this method.

From Fig. 6a, various time paths are traced out to correspond to production planning schedules. These paths, Fig. 6b, show that the controlling series of events requires 22 months.

Such networks become very complex for large projects. Use of the pictorial device allows the planner to be sure that the chain is properly linked. Actual determination of the critical path may be worked out on an electronic computer. As a further refinement, minimum and maximum times as well as expected times for events for the completion of the various stages may be included.

Finally, the engineering manager must consider

both his manpower and his available facilities. These should be evaluated in the light of schedule requirements to determine whether or not the schedule can be met.

Short-Range Planning

Short-range planning deals with the current year. It represents the tactics and maneuvering required to make short-term adjustments which are consistent with longer-range plans. For example, if schedules are slipping, planning is necessary to overcome this problem. A key man may resign, laboratory facilities may break down temporarily, manufacturing people may have a chronic problem with engineering liaison, etc. All these and other engineering problems which cannot be foreseen may arise. They require careful planning by the engineering manager.

Short-range planning is usually done under pressure of time and events. The engineering manager should anticipate problems and consider possible solutions. If he does so, he will be better off than if he simply waits for the problems to develop.

Planning, control, and measurement are all closely related. Short-range planning is especially concerned with control and measurement, since these latter activities indicate when immediate action must be taken. The engineering manager does not need to wait until things come to a standstill before recognizing that a problem exists. Through the control system, he is made aware of problems as soon as they arise.

Frequently the engineering manager is required to evaluate proposals made by subordinates. The test for new plans proposed by subordinates is to determine if such plans will facilitate short-range, intermediate-range or long-range objectives.

When to Plan

Short-range planning is generally carried out as time and events dictate. The efficient manager tries to schedule major action for the month ahead. In addition, he holds weekly staff meetings to review problems and make sure that his managers are planning their own work to keep operations moving smoothly.

Most progressive companies carry out formal long-range and intermediate-range planning annually, although intermediate reviews may be made as often as twice a year.

The annual forecasting and planning session often concludes with a business review. This is a formal report on progress and future plans. The objective is, of course, to obtain the approval of the forward planning by the officers of the company.

The engineering manager should be careful that his outline is clear, that the justification for his plans is not buried in a mass of complex detailed charts, and that his presentation is directed towards businessmen rather than technical specialists. He should, however, be prepared to answer any technical questions which may be asked.

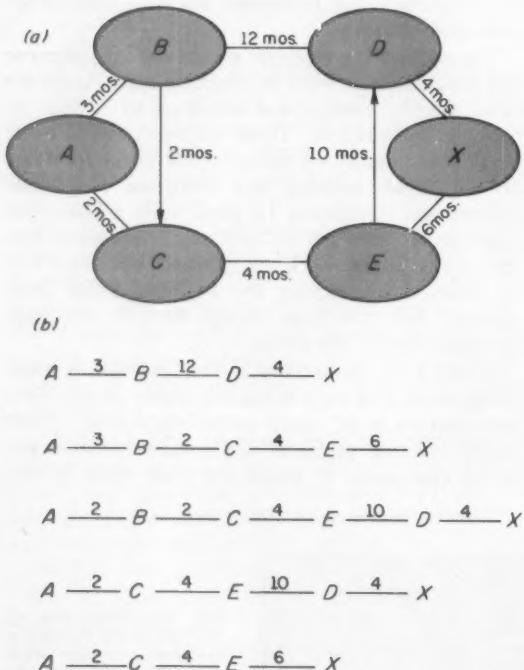
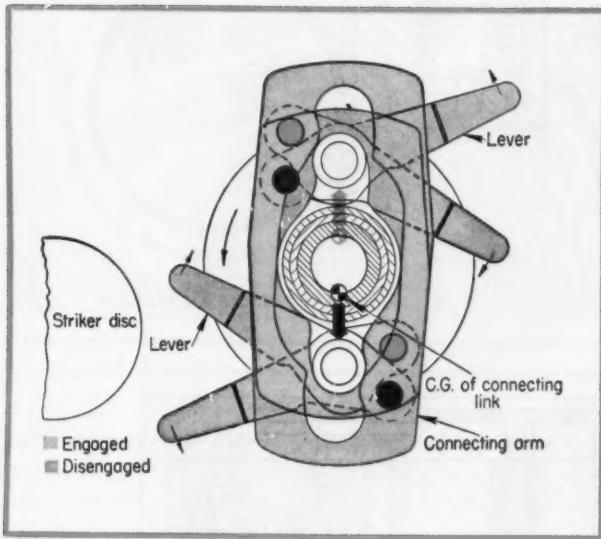
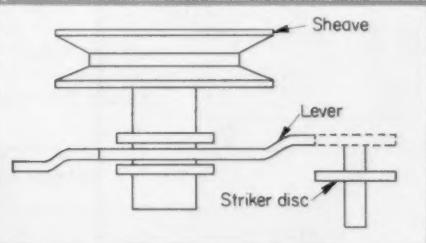
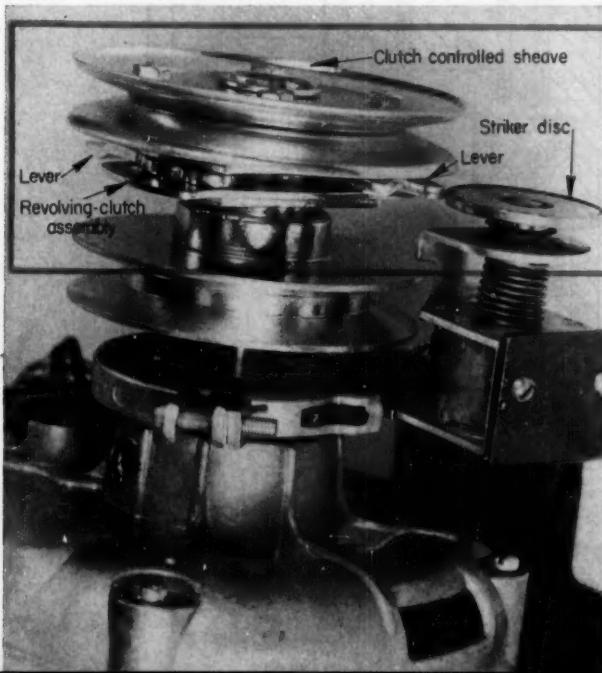


Fig. 6—PERT method of connecting production events by time-links for intermediate-range planning, *a*, and time paths taken from the graphical representation, *b*. This method provides a ready indication of the maximum time required for a project, and shows where savings in time and effort can be made.

scanning the field for *ideas*

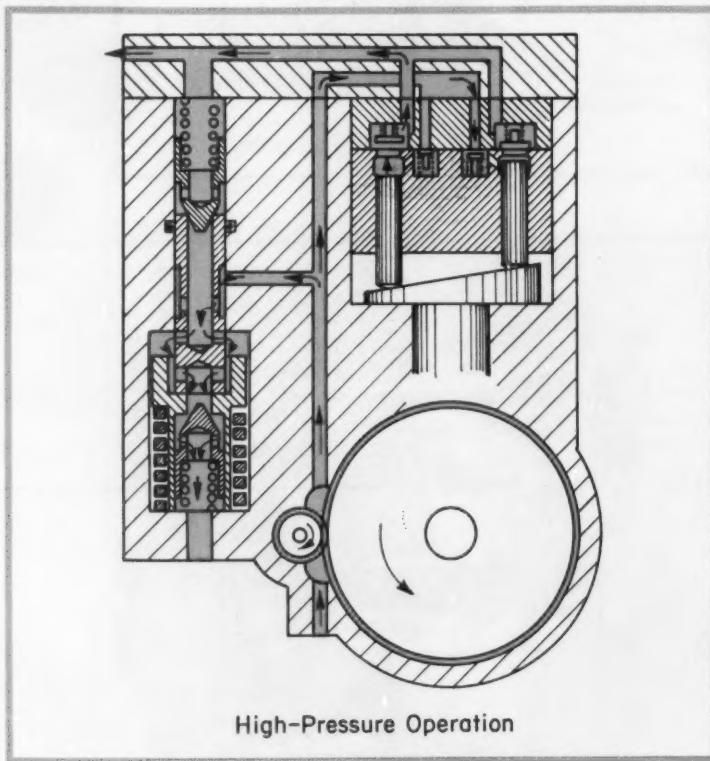
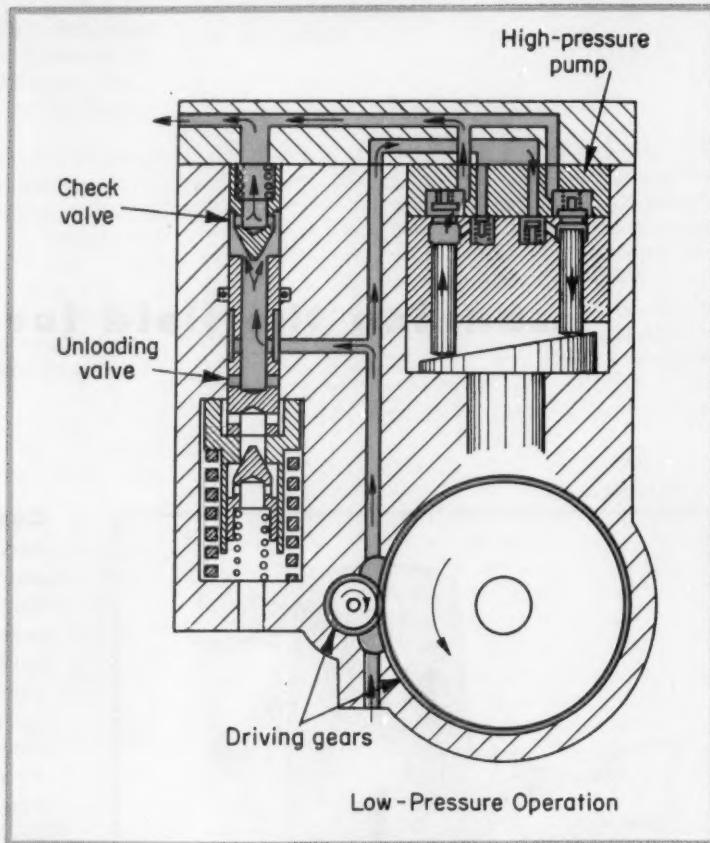


Center-of-gravity shift provides overcenter action to complete clutch engagement or disengagement. To actuate the clutch, a striker extends into the path of one of the revolving levers. This action shifts the center of gravity of the connecting arm to the opposite side of the power shaft. Centrifugal force then completes the movement, which shifts the arms enough to clear the striker disc. Principle employed in a clutch by Spring Div. of Borg-Warner Corp., Bellwood, Ill.



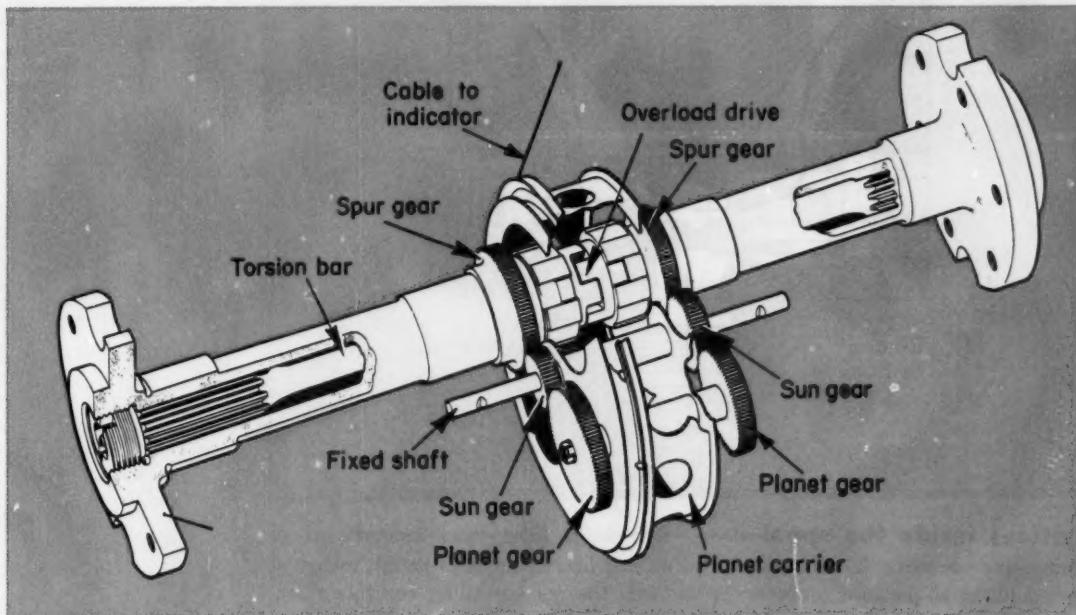
SCANNING THE FIELD FOR IDEAS

Driving gears pump oil in addition to transmitting power to high-pressure pump. The low-pressure, high-volume output of the gear set is used to supercharge the inlet of the axial - piston high - pressure pump. During low-pressure operation, gear pump flow joins the flow from the piston pump. At higher pressures, a pressure-operated valve unloads the gear pump so that it provides only the supercharging pressure for the piston pump. Principle employed in pump by Owatonna Tool Co., Owatonna, Minn.

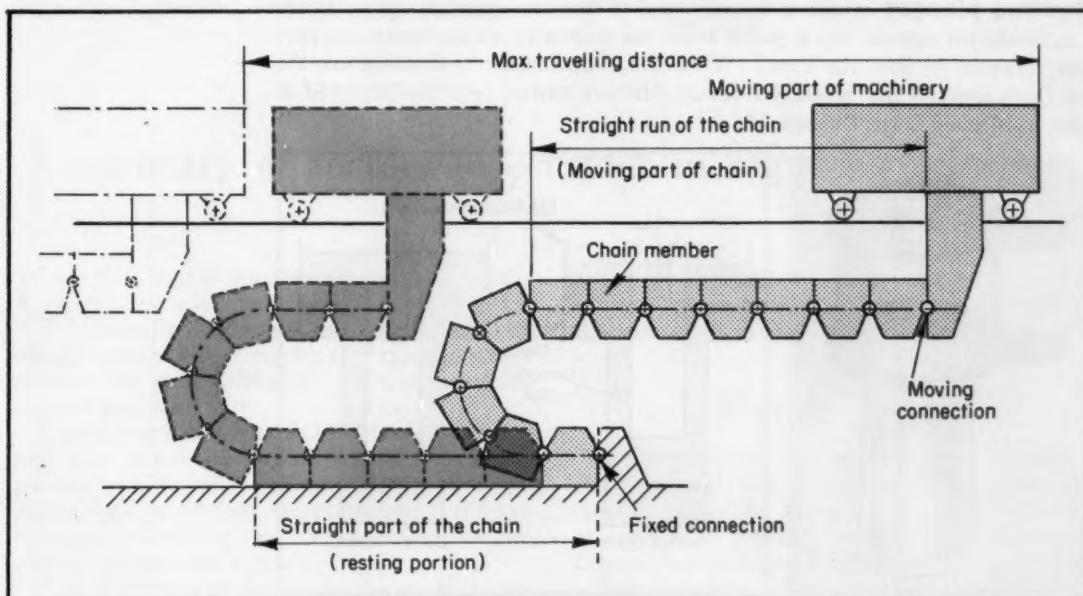


Wind-up of a double planetary measures torsion bar deflection to determine transmitted torque. One planet gear of each planetary set is carried in a common carrier which is free to rotate around the sun gear. The other planet gears are each driven from opposite ends of the torsion bar. Thus torsion-

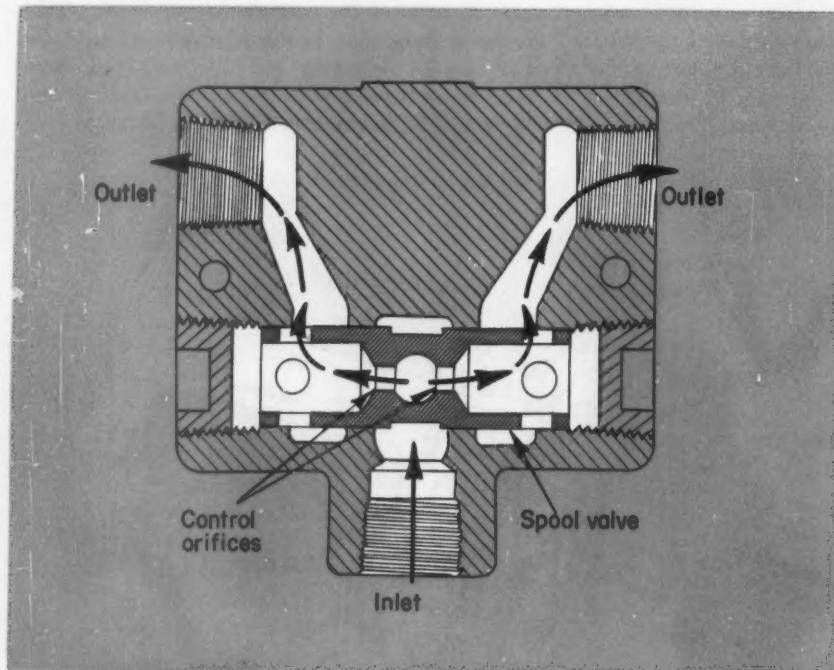
bar windup produces relative rotation of the attached gears. Reaction of the gear train displaces the planet carrier in proportion to the relative rotation of the shaft gears. Measuring principle employed in a torquemeter developed by Sir George Godfrey and Partners Ltd., Hanworth, Middlesex, England.



Self-supporting chain links carry hose or cables supplying a movable part of a machine. Vertical link faces above each pin resist sagging of the chain under load. Principle employed in cable carrier by Gleason Reel Corp., Mayville, Wis.

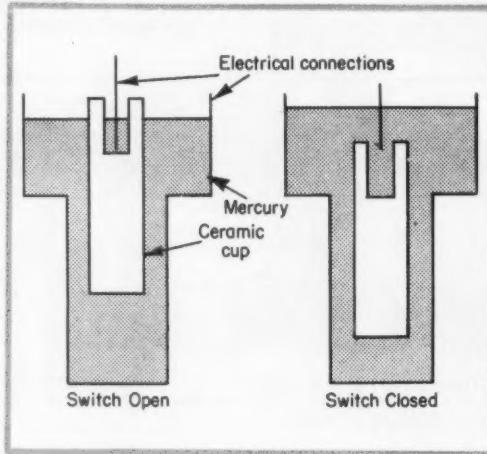
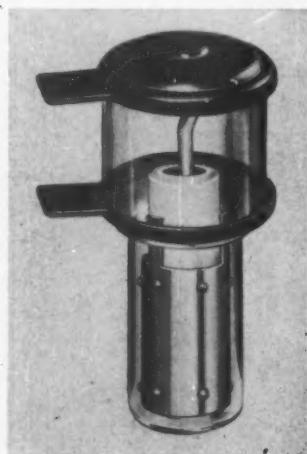


SCANNING THE FIELD FOR IDEAS



Orifices inside the spool divide flow in a fixed ratio independent of branch-line pressures. If a decreased load on one branch tends to permit increased flow, additional pressure drop occurs through the corresponding control orifice. The unbalanced force on the spool valve then repositions it so that the flow passage to that branch is partially closed. Principle employed in a hydraulic flow equalizer by Brand Hydraulics, Omaha, Nebr.

Floating plunger divides a mercury pool to open an electrical circuit. When a metal-sleeved ceramic cup is pulled below the surface by an electromagnet, mercury flows in to close the circuit. When the electromagnet is de-energized, the cup floats upward and breaks the circuit. Mercury-contact principle employed in relay by Mercoid Corp., Chicago, Ill.



Basic principles of Pressure Regulators

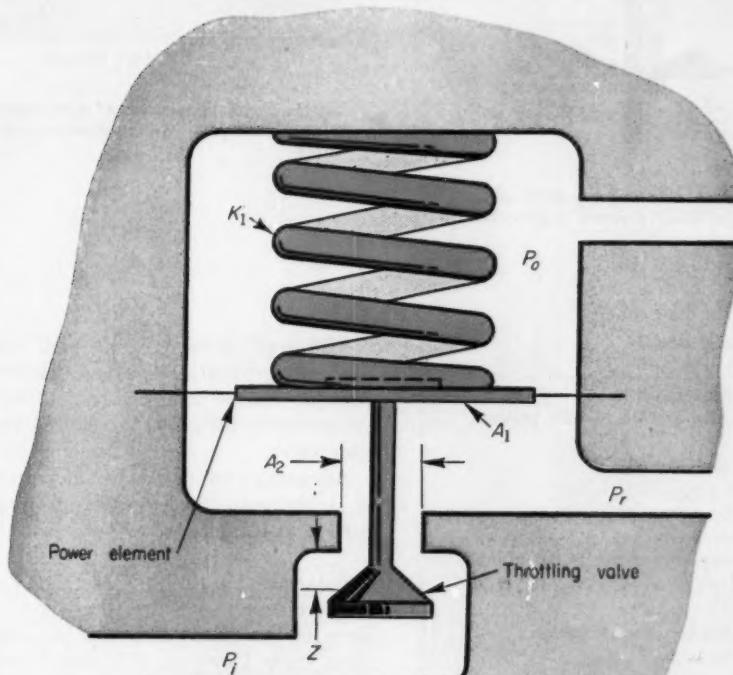


Fig. 1—Basic pressure regulator.

JOHN KARPUS

Engineering Manager
Research and Development
National Water Lift Co.
Kalamazoo, Mich.

A summary of factors to consider in regulator selection.

CONTROLLED transmission of gases usually requires some form of pressure regulation. Generally, a pressure-regulating device must operate independent of varying flow rate and supply pressure and must deliver the gas at a reasonably constant pressure.

Applications range from those of low supply pressure with infinite capacity to those of high supply pressure with limited capacity. In some applications, manual adjustment can compensate for variations in supply pressure or flow rate. In others, no correction or adjustment is possible.

This article reviews the factors that must be con-

sidered in selecting the best regulator for a particular application or in adapting requirements to the performance available.

Simple Types

The pressure regulator has three essential elements—a throttling valve to regulate flow, a power element to move the throttling valve, and a means of applying a preload force which establishes the demand level of the regulated pressure.

Basic Regulator: This device, Fig. 1, has the three

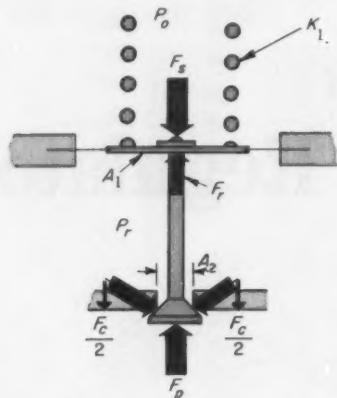


Fig. 2—Free-body diagram of throttling valve of basic pressure regulator.

Nomenclature

- A_1 = Effective area of diaphragm, sq in.
- A_2 = Unbalance area of valve exposed to inlet pressure, sq in.
- F_c = Force required to seat valve, lb
- F_s = Unbalanced force on valve, lb
- F_r = Force produced by diaphragm, lb
- F_p = Force produced by spring, lb
- K_1 = Spring rate of power-element spring, lb per in.
- K_2 = Spring rate of throttle-valve return spring, lb per in.
- P_i = Inlet pressure, psi
- P_o = Reference pressure (assume equal to zero)
- P_r = Regulated outlet pressure, psi
- ΔP = Change in regulated outlet pressure, psi
- X = Deflection of power-element spring at initial operating condition, in.
- ΔX = Change in spring deflection from initial operating condition, in.
- Y = Deflection of throttle-valve return spring at initial operating condition, in.
- Z = Amount of valve opening, in.
- ΔZ = Change in amount of valve opening, in.
- ΔZ_m = Valve opening when P_i is at maximum value, in.
- ΔZ_m = Valve opening when P_i is at minimum value, in.

elements in their simplest forms: 1. A helical compression spring which is normally adjustable externally; 2. A diaphragm or bellows, exposed to regulated pressure, which opposes the spring. 3. A throttling valve, attached to the diaphragm, which controls the entry of the high-pressure gas into the regulated-pressure chamber.

Normally, in a basic regulator, a simple throttling valve is exposed to supply pressure.

This type regulator is used if the supply pressure is essentially constant. Under this condition, the force produced by the unbalanced throttling valve is almost a constant and can be cancelled by a simple readjustment of the preload.

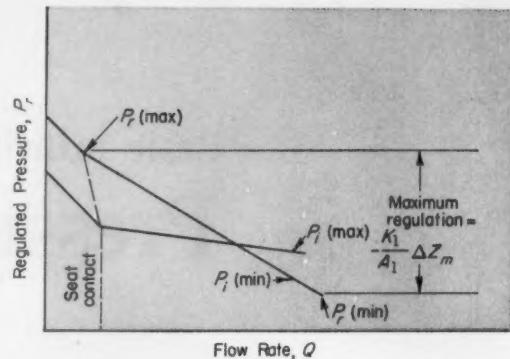


Fig. 3—Regulation curves of a regulator with small unbalanced area and with unbalanced force opposing the spring.

This type regulator works well with average factory compressed-air systems. However, if supply pressure varies appreciably, output pressure also varies due to the large unbalanced area in the throttling valve.

Advantages of this valve include simplicity, ease of adjustment, ruggedness, and freedom from the need of attention.

Balanced Throttling Valve: For operation with a varying supply pressure, this type valve overcomes some of the disadvantages of an unbalanced throttling valve. However, it is almost impossible to balance this type valve completely. The accumulation of normal manufacturing tolerances often causes unbalances. For critical applications, careful control of the area of throttling-valve unbalance should be maintained. Here, both the magnitude and direction of the force created by the residual unbalance area should be considered.

Gaseous Spring: This regulator is relatively simple, but it is not suitable for unattended service. The chamber normally occupied by the spring is filled with gas under pressure. This pressure acts on the diaphragm and establishes a reference pressure. When the regulated pressure equals the reference pressure the diaphragm closes the throttling valve. Advantages are its small size and the good regulation provided by the low spring rate.

Variations

Two or more basic regulators can be used in series to overcome the problem of a widely variable supply pressure. The first regulator provides coarse control. Thus, the supply pressure to the second stage is relatively constant. The main disadvantage is the additional space required for the multiple stages.

A pilot valve can be used to control the main power element. In a pilot-valve controlled regulator, a

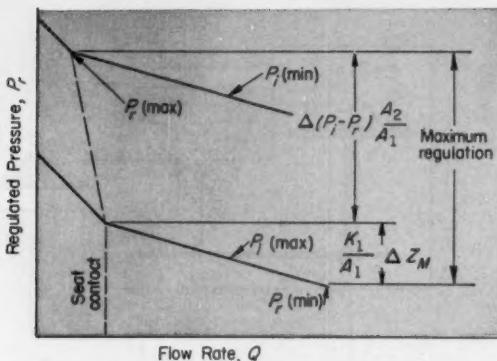


Fig. 4—Regulation curves of a regulator with large unbalanced area and with unbalanced force opposing the spring.

small movement of the pilot valve controls the travel of the power element. The disadvantages are complexity, slow response to pressure changes, instability, and the continuous gas loss through the pilot stage.

Operating Characteristics

However, for many applications the pilot-operated regulator can produce the most accurate regulation.

A change in operating temperature produces a calibration shift by altering the spring rate of the system. Normally, the spring rate increases as the temperature falls, and decreases as the temperature rises. In most cases, this temperature effect can be neglected. However, for such special service requirements as the pilot-operated regulator, temperature compensation of the spring setting may be required.

Positive sealing for leak-free operation requires good contact between the valve and seat. To produce this seal, a "lock-up" force is required. This additional force should be considered in the selection of this type regulator.

A free body of the throttling valve of the basic regulator is shown in Fig. 2. Solution and rearrangement of the free-body force equations yields

$$\Delta P_r = -\frac{K_1 \Delta Z}{A_1} - \Delta(P_i - P_r) \frac{A_2}{A_1} \quad (1)$$

Thus, for the best regulation the regulator should have low spring rate K_1 , large area in the power element A_1 , and small unbalance ratio A_2/A_1 .

If inlet pressure P_i is constant, $(P_i - P_r)$ changes very little. Then, if A_2/A_1 is small, $(P_i - P_r) A_2/A_1$ can be considered equal to zero. Thus Equation 1 can be simplified to

$$\Delta P_r = -\frac{K_1 \Delta Z}{A_1} \quad (2)$$

Flow of a gas through a regulator is a function of ΔZ , P_r/P_i , and the gas density. As shown in Fig. 3,

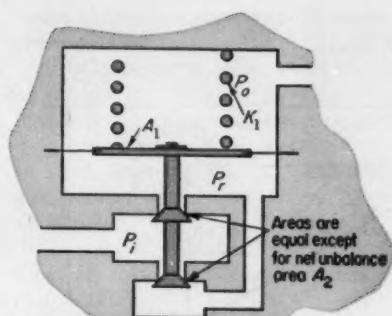


Fig. 5—Double-seating balanced throttling valve.

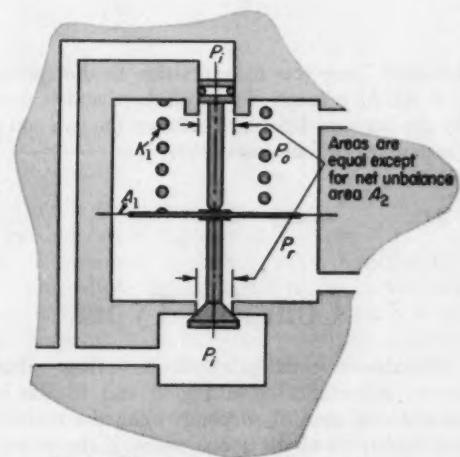


Fig. 6—Piston-type balanced throttling valve.

the slope of the pressure-vs-flow line increases as P_i decreases, because ΔZ increases for each value of flow.

Force is required to provide the valve-to-seat contact necessary for complete shut-off. The force required depends on the finish of the seat, the area in contact, and the spring rate of the seat material. In Fig. 2 this force is shown as F_e . After seat contact, there is no further deflection of the main spring. Thus, the magnitude of F_e depends upon the increase in regulated pressure and on diaphragm area A_1 .

If ratio A_2/A_1 is large, the family of curves is arranged as shown in Fig. 4. The spread is proportional to ratio A_2/A_1 .

If ratio A_2/A_1 is small, the maximum regulation band is defined as:

$$\Delta P_r = -\frac{K_1}{A_1} \Delta Z_m \quad (3)$$

Equation 3 defines the regulation of the valve over the range of its flow capacity when pressure ratio P_r/P_i is maximum. The unbalanced area and the unbalanced pressure do not add to the total regulation band if ratio A_2/A_1 is small and if the un-

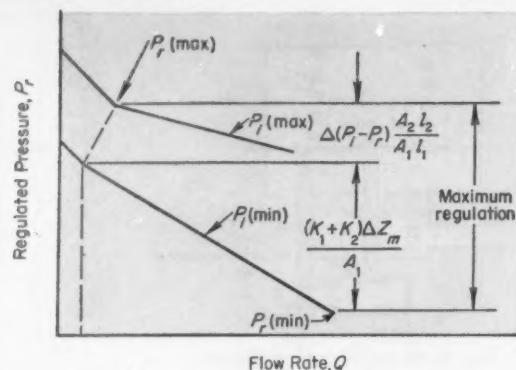


Fig. 7—Regulation curves of a balanced-type regulator with a slight unbalance and with unbalanced force added to the spring.

balanced force acts in opposition to the spring.

If A_2/A_1 is large, the regulation band is described by the pressure difference between the two end points (maximum and minimum P_r).

$$\Delta P_r = -\frac{K_1}{A_1} \Delta Z_m - \Delta(P_i - P_r) \frac{A_2}{A_1} \quad (4)$$

Complex Types

Regulators with balanced throttling valves are shown schematically in Fig. 5 and 6. Size of the unbalanced area, A_2 depends upon the manufacturing variations of the components. If the unbalanced force is small and in an upward direction, the regulation is defined by Equation 3 and the family of curves as in Fig. 3. If the unbalanced force is in the opposite direction, regulation is defined by

$$\Delta P_r = -\frac{K_1}{A_1} \Delta Z_m - \Delta(P_i - P_r) \frac{A_2}{A_1} \quad (5)$$

and the family of regulation curves of Fig. 7.

Best regulation is obtained when ratio A_2/A_1 is small and the net unbalanced force is in the upward or positive direction. The net regulation is then equal to that determined by the spring rate of the system only.

For special uses, the balanced throttle valve regulator can produce zero regulation over a wide range of inlet pressures while maintaining a constant flow rate. To do so, the unbalance area must be

$$A_2 = \frac{K_1 \Delta Z}{\Delta P_i} \quad (6)$$

The double-seating valve, Fig. 5, complicates the manufacture of the regulator. The arrangement of Fig. 6 reduces the manufacturing complications, but the sealing O-ring causes undesirable friction.

A lever-link regulator is shown in Fig. 8. The mechanical advantage aids the power diaphragm in controlling the throttling valve.

Moments can be taken about the pivot point, and

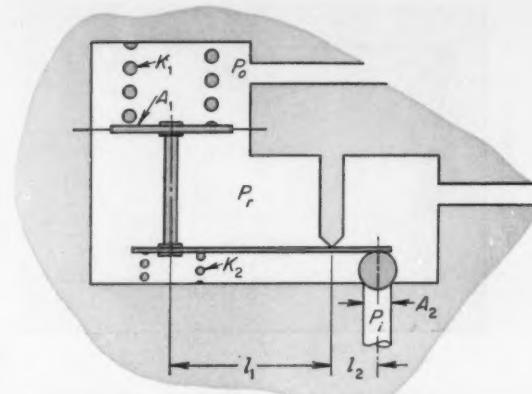


Fig. 8—Lever-link regulator.

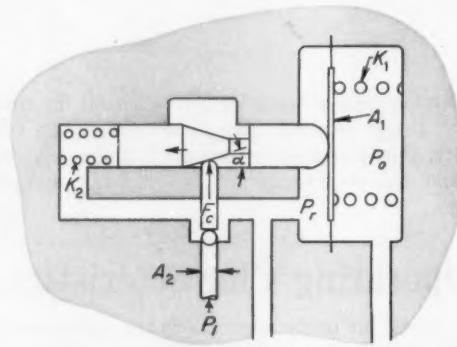


Fig. 9—Cam-link regulator.

the equation solved for the regulated pressure.

$$P_r = \frac{K_1 X}{A_1} + (P_i - P_r) \frac{A_2 l_2}{A_1 l_1} - \frac{K_2 Y}{A_1} \quad (7)$$

A cam-link regulator is shown in Fig. 9. The cam provides the mechanical advantage analogous to the lever of Fig. 8. Regulated pressure can be determined in a similar manner.

$$P_r = \frac{K_1 X}{A_1} + (P_i - P_r) \frac{A_2}{A_1} \tan \alpha - \frac{K_2 Y}{A_1} \quad (8)$$

Friction of the cam and associated elements is greater than that of the lever fulcrum which can be a knife edge, friction-free bearing, or equivalent.

The regulation of the lever-link regulator is shown in Fig. 10. The lever-link regulator has one basic advantage—the ability to increase the valve seating force.

Design Evaluation

The primary factors in the control of pressure by a mechanical regulator are the system spring rate, the effective area of the power element, the

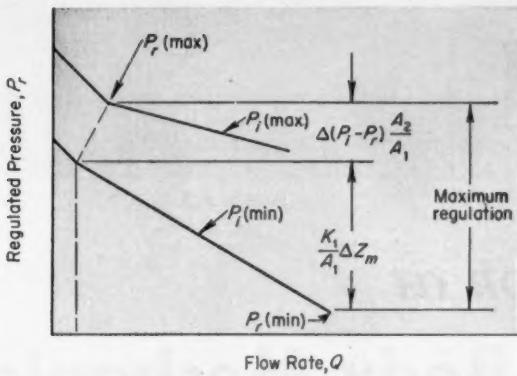


Fig. 10—Regulation curves of a lever-link or cam-link regulator.

Tips and Techniques

Double Linear Interpolation

The following example illustrates a simple, direct method of double interpolation.

K = 0.70				K = 0.72				
P	0.01	0.02	0.03	0.04	0.01	0.02	0.03	0.04
R	1.12	1.14(a)	1.17(b)	1.19	1.31	1.32(c)	1.35(d)	1.39

Find R if P = 0.026; K = 0.705.

1. Calculate x and y:

$$x = \frac{0.026 - 0.020}{.010} = 0.6$$

$$y = \frac{0.705 - 0.700}{0.020} = 0.25$$

where the numerator in each case is the difference between the given value and the nearest lesser tabular value, and the denominator is the incremental value of P and K respectively.

2. Then, from

$$R = a(1-x)(1-y) + bx(1-y) + cy(1-x) + dxy$$

calculate the value of R.

$$R = 1.14(0.4)(0.75) + 1.17(0.6)(0.75) + 1.32(0.25)(0.4) + 1.35(0.6)(0.25) = 1.203$$

—WILLIAM GRIFFEL, Picatinny Arsenal, Dover, N. J.

Dividing Angles into Parts

A compass can be used to divide an angle into any number of parts. The following example illustrates the method. Angle AON is to be divided into

range of inlet pressure, and the area exposed to inlet pressure.

A balanced-type valve with a small unbalance in the correct direction gives the best over-all performance. By the correct selection of the unbalanced area, this type can be independent of the change in inlet pressure, Fig. 3. This regulator can also give almost perfect regulation if constant flow is desired.

All other combinations produce a wider regulation band (if the same dimensions and operating range are used).

The lever-link regulator should be considered for use in low-leakage systems because of its ability to multiply the valve seating forces. However, regulation is increased because the mechanical advantage of the lever multiplies the mechanical spring rate.

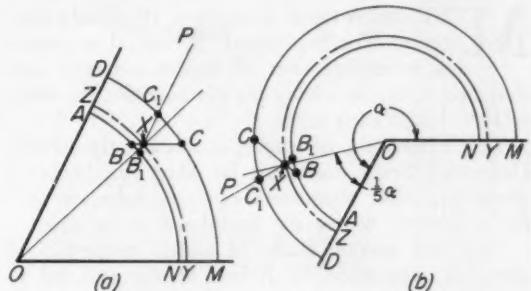
n parts (in this case, three parts), a.

1. Draw arc NA with center at O.

2. Set the compass to slightly more than the distance NA/n , where NA = length of the chord; and n = number of parts into which the angle is to be divided. From point N, measure twice this distance and mark point B. Generally, the distance to be marked is $(n-1)(NA/n)$.

3. With the same compass setting as in Step 2, from A measure distance NA/n and mark point B_1 .

4. Draw line B_1P approximately parallel to AO .



Draw any arc DM and mark point C_1 .

5. From point M, find point C so that $MC = 2DC_1$.

6. Point X is the intersection of lines BC and B_1C_1 . Then, angle ZOX is equal to one-third of angle AON (in general, $1/n$ of angle AON).

The illustration in b shows the process used to divide an angle larger than 180 deg. The angle in this case is to be divided into five parts. The process is identical.—W. HANKA, Sierras De Cordoba, Argentina.

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A new look at **Elastic-Body Mechanics**

*... the facts about eight neglected concepts
that offer practical possibilities in design*

C. W. MUSSER

Research Adviser

United Shoe Machinery Corp.
Boston, Mass.

MOST design today is based on rigid-body concepts. The traditional theoretical approach is to assume that all bodies are rigid and that two points in a body always maintain the same relationship to each other.

This hypothesis, of course, is not strictly correct. Deflections occur and must be taken into account, along with other phenomena of elastic behavior. But, for simplicity, bodies are considered to be rigid.

The first serious study of elastic properties of materials was made by Robert Hooke and led to the development of his now well-known stress-strain relationship, which was published in a paper in 1675. The development of the spring as an effective energy-storage device based on elastic principles can be largely traced to this work.

Since Hooke's early contributions, there has been little progress in this field. Recently, however, an extensive research program has been undertaken to explore the possibilities for use of elastic properties as the key to solution of design problems. Results of that investigation are reported here.

Basic Principles

Many theoretical studies have been made of the principles of elastokinetics in general, and of elasto-

dynamics in particular. The principles that have been investigated are:

1. Arcuation	5. Scalloping
2. Integration	6. Differential
3. Interfacial strain	7. Poisson's wedge
4. Torsion lever	8. Twisted strip

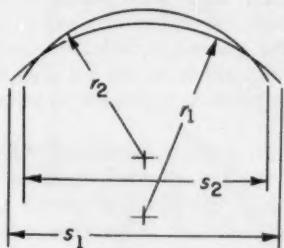
These principles are summarized in Table 1.

Arcuation: A change in curvature of an arc produces a change in the arc's chordal length. This principle is similar to that of a semielliptic spring in an automobile, where one end is fixed in a pivot and the other end is left to move in a swinging shackle, allowing for the change in curvature of the spring with vertical motion of the axle. Here, the change in chordal length is a function of the change in radius of curvature of the arc.

Integration: In a right cylindrical tube, one end of the tube can be deflected into an ellipsoid, which will have a major and minor axis, while the other end remains circular. If the major and minor axes of the ellipsoidal shape are rotated without physically rotating the tube, some points on the periphery of the ellipsoid will move at a different angular velocity than other points. With the circular end of the tube stationary, some of these points will

Table 1—Principles of Elastodynamics

Arcuation

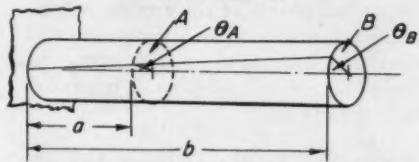


The difference between chordal lengths s_1 and s_2 is a function of the change in radius r_1 :

$$s_1 - s_2 = f(r_1 - r_2)$$

$$\Delta s = f(\Delta r)$$

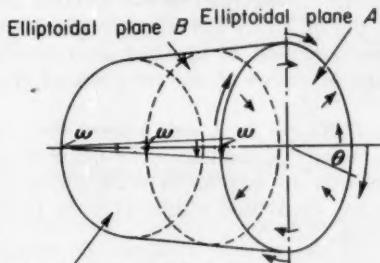
Torsion Lever



Angular rotation of a cross-sectional plane in a twisted uniform bar bears the same proportional relation to the maximum angular rotation in the bar as its axial position in the bar does to the axial position of the plane of maximum rotation:

$$\theta_A = \theta_B \frac{a}{b}$$

Integration

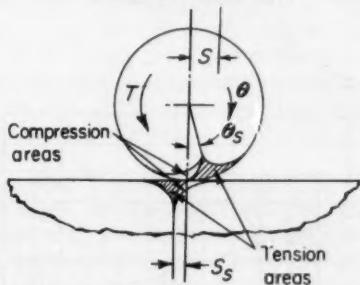


Circular plane C (All points on circumference angularly stationary)

When the elliptoidal shape of the end of a right cylindrical tube (with the one end deflected into an elliptoid) is rotated, the summation or integration of the angular velocities of all peripheral points of any cross-sectional plane equals the summation or integration of the angular velocities of all peripheral points of any other cross-sectional plane:

$$\oint_{PA} \omega ds = \oint_{PB} \omega ds$$

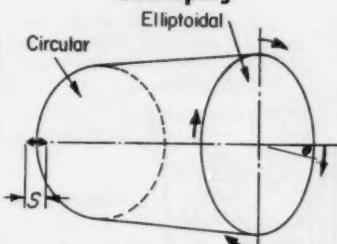
Interfacial Strain



The distance traversed by an element rolling on a surface is a function of the direction and amount of the tangential shear strain at its interface:

$$S = f(\theta \gamma_t)$$

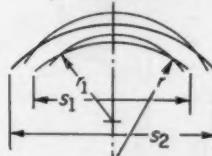
Scalloping



In a right cylindrical tube with one end deflected into an elliptoid, rotation of the major-minor axes of the elliptoid causes axial movement of the circular end:

$$S = f(\theta)$$

Differential



In parallel arcs, the difference in chordal length is a function of the radius of curvature:

$$s_2 = s_1 = f(r)$$

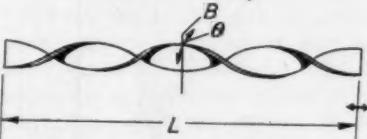
Poisson's Wedge



The change in diameter is a function of the change in length:

$$\Delta D = f(L)$$

Twisted Strip



A small change in length L produces rotation of cross section in plane B:

$$\theta_B = f(L)$$

have a positive angular velocity in relation to the movement of the shape, while other points will have a negative angular velocity. The two points on the major axis will have the highest positive angular velocity, and the two points on the minor axis will have the highest negative angular velocity. The summation or integration of the angular velocities of all peripheral points of any cross sectional plane will equal the summation or integration of the angular velocities of all peripheral points of any other cross sectional plane.

Interfacial Strain: This strain condition is brought about by the tangential shear strain at an interface caused by torque applied to a member rolling on a surface. At the interface, this torque produces compression of the material on one side of the contact, and tension on the opposite side. This pattern is reversed on the contacted surface. Although this effect has been studied before, particularly in ball

bearings, it has not been recognized as a useful design tool. As will be shown later, this principle has been applied to produce a mechanical torque converter.

Torsion Lever: When a bar is torsionally deflected, the angular deflection at any point along its length depends on the axial position of this point. Hence, angular rotation of a cross sectional plane in a twisted uniform bar bears the same proportional relation to the maximum angular rotation in the bar as its axial position in the bar does to the axial position of the plane of maximum rotation.

Scalloping: In a right cylindrical tube with one end deflected into an ellipsoid, rotation of the major-minor axes of the ellipsoid causes axial movement of the circular end. This axial motion is such that the periphery of the circle does not lie in a plane. The parts of the periphery along the major axis of the ellipsoid are displaced away from the ellipsoid and the points along the minor axis are displaced toward the ellipsoid.

Differential: If the radii of two parallel arcs are changed, the difference between the chordal length of the two arcs will be changed as a function of the change in radius of the curvature of the arcs.

Poisson's Wedge: It is well known that, due to Poisson's ratio, the diameter of a bar will change with a change in length. In some instances, this principle has been used satisfactorily to produce a wedge action.

Twisted Strip: If a thin strip of material is twisted so as to form a right hand and a left hand helicoid from the center, it can be used for measuring minute changes in length. A small change in the length will produce a relatively large rotation of the cross section in the center of the twisted strip. This principle has been applied in a sensitive extensometer.

Application Concepts

The applied-mechanics aspect of elastic-body mechanics, or elastokinetics, might be called elastokinetics, since time, displacement, and force are always factors. The tools of elastokinetics are the

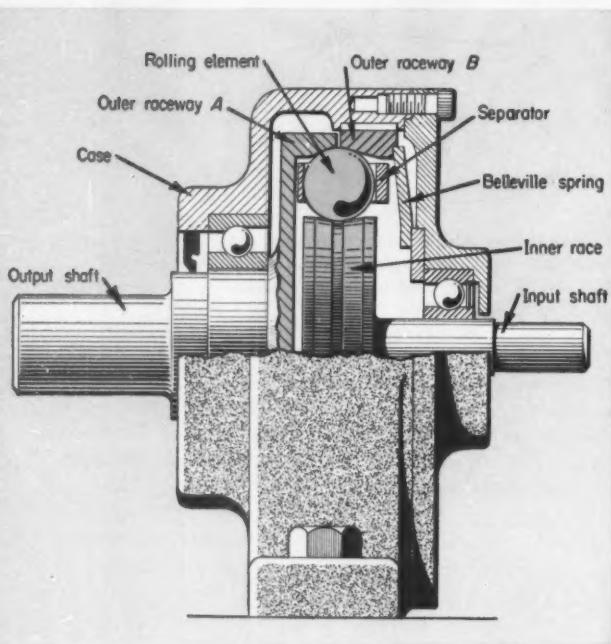
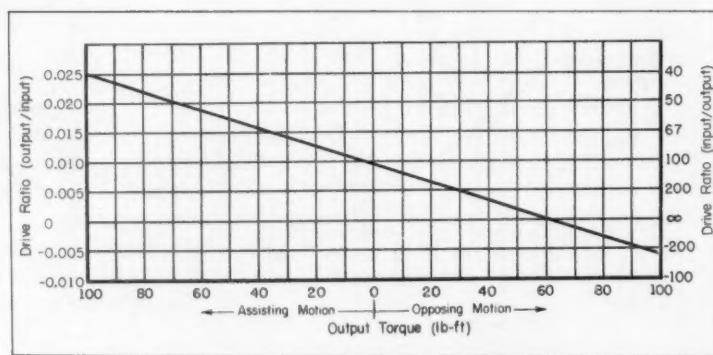


Fig. 1—Operating elements of a mechanical torque converter that utilizes interfacial strain to regulate drive ratio.

Fig. 2—Relationship of output torque to drive ratio for torque converter in Fig. 1. Plot based on experimental data shows that tangential shear strain is proportional to load.



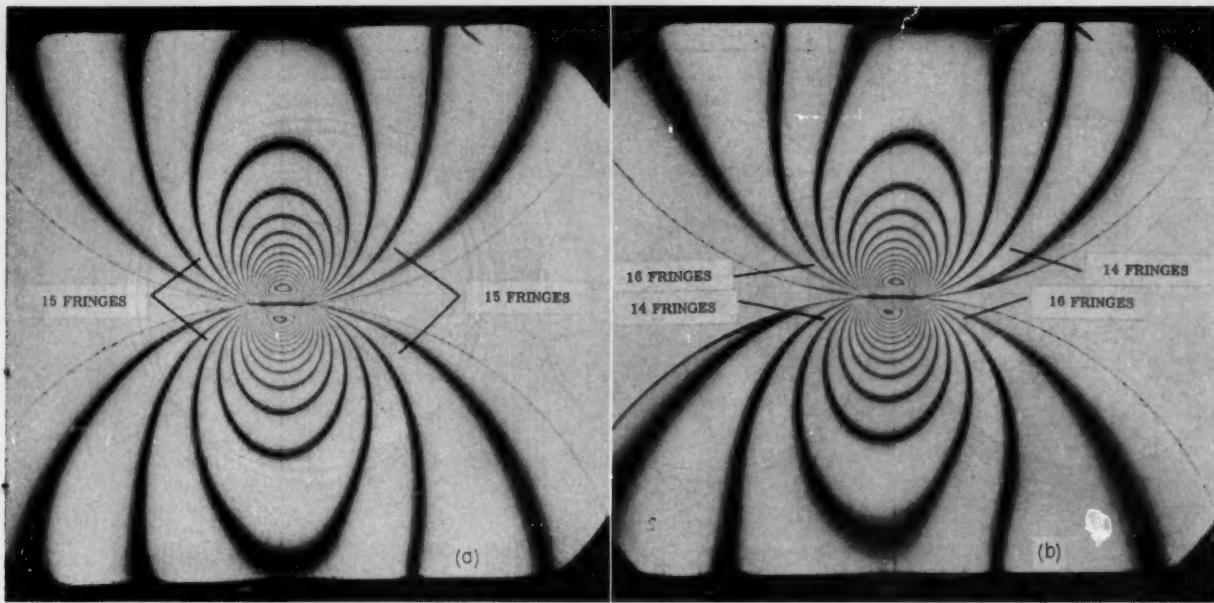


Fig. 3—Birefringement lines at the interface of two plastic discs. When the discs are radially loaded, *a*, almost perfect symmetry prevails. However, when a torque load is applied to the discs to create tangential shear strain, *b*, the symmetry is destroyed.

modifiers of motion and force: The lever, the wedge, and strain.

The lever and the wedge considered here bear no resemblance to the lever and the wedge of rigid-body mechanics except in the result produced. The third element, strain, sounds somewhat strange as a tool, but certain modifications of motion which are produced by this strain cannot be classed with either of the other tools.

Some of these "tools" are well known. However, their newness lies in their use as basic design tools. Deflection, for example, has been known for many centuries. However, it usually has been considered an objectionable feature in a mechanism, and there has been much effort to eliminate it. The only exception is in springs, where deflection is used solely for storing energy. However, the use of deflection as a lever or as a wedge was not considered prior to this study.

Many of the principles and tools previously mentioned have already been put to practical use. Details of all of these applications are beyond the scope of this article; however, two developments merit particular attention.

Mechanical Torque Converter: The first major breakthrough in the application of elastokinetics principles was the development of a mechanical torque converter, Fig. 1, utilizing the principles of interfacial strain to obtain the required action. Essentially, this unit functions as a differential planetary system, employing what appears to be a radial ball bearing with a split outer race. Since the angles of the raceways of the two halves of the outer race are different, the effective diameters of the rolling

elements are also different. As a consequence, rotation of the inner race causes one outer raceway to move angularly in relation to the other outer raceway. In Fig. 1, outer raceway *B* is splined to the case and is urged towards outer raceway *A* by the Belleville spring. Since outer raceway *A* is connected directly to the output shaft, rolling the balls around raceways *A* and *B* by turning the inner race through the input shaft will cause relative motion of the output raceway *A*. The separator is used to space the balls in a manner similar to that used in ball bearings.

The entire unit functions as a reduction converter with a basic ratio of 100:1 in the design shown. However, when a torque is applied to the output shaft, it causes outer raceway *A* to set up a tangential shear strain at the points where it contacts the rolling ball elements. At the interface between the rolling elements and raceway, this strain tends to compact the material on one side of the interface of the raceway, and to stretch the material on the other side. This strain pattern is reversed on the ball.

This action sets up a force that tends to rotate the ball, producing a similar but opposite interfacial strain between raceway *B* and the rolling ball elements. It also sets up interfacial strain between the rolling elements and each raceway of the inner race. Under this applied torque, eight individual surfaces per rolling element come into play, each with an amount of tangential shear strain directly dependent on the output torque.

Under these conditions, the ratio no longer remains 100:1 but changes as a function of output torque. This relationship is shown by the graph,

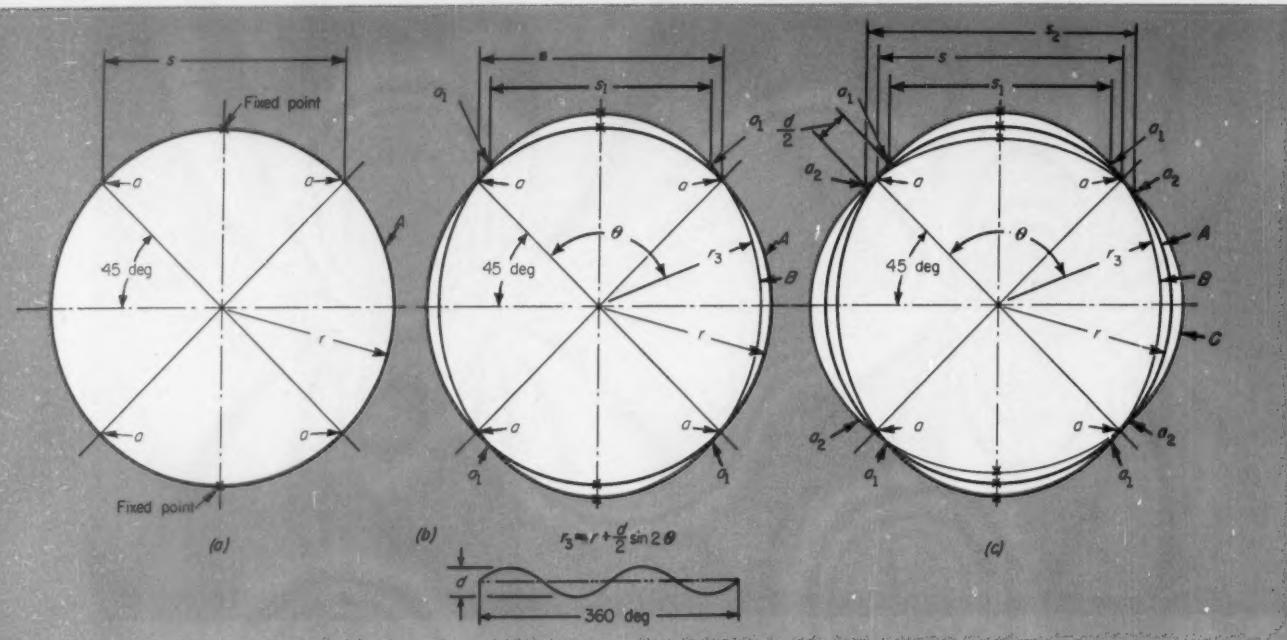


Fig. 4—Effect of superimposing a sine wave on a circular element. Basic element, *a*, is shown with sine wave superimposed at *b*, and with wave advanced 180 deg at *c*.

Fig. 2, which is based on experimental data. The straight-line plot produced by the data indicates that the tangential shear strain is proportional to the load, just as the shear modulus is. It can be seen that while the drive ratio (input/output) at zero output torque is approximately 100:1, this ratio can be varied from about 55:1, with an assisting torque of 60 lb-ft, to infinity, with an opposing torque of 60 lb-ft. This indicates that an automobile wheel makes more revolutions per mile going up a hill than in going down.

Examination of the birefringent lines on plastic specimens under various types of loading and reaction at the interface clarifies this concept. Fig. 3a shows two discs under radial loading. Almost perfect symmetry prevails, and the same number of fringes appear on each side of the radial line. However, when a torque load is applied to the discs to create a tangential shear strain at the interface, Fig. 3b, the birefringent lines no longer create a symmetrical pattern. As they skew away from the radial lines, they tend to add a fringe to one side and to subtract a fringe from the other.

Thus, the model without torque loading has 15 fringes on each side while the model with torque loading has 14 fringes on one side of the interface and 16 fringes on the other side, with a reversed pattern on the contacted roller. While it is not strictly true, it can be generally concluded that rotating these discs together in one direction would give a 14:16 ratio, and rotating them in the other direction would give a 16:14 ratio.

At first glance, this effect may not appear large enough to be useful. However, when it is incorpo-

rated into a differential mechanism and multiplied by many contact points, only a small change in ratio is required at each interface to produce a very large change in over-all ratio.

Harmonic Drive: Arcuation (Table 1) is one of the most useful lever principles in elastodynamics. However, for maximum effectiveness, it is desirable to apply this principle so that the action is continuous. This can be accomplished by using a circular element. Since a circle is actually composed of a series of arcs, changing the curvature of the individual arcs will cause angular motions of portions of the circle in relation to other portions. This concept is illustrated in Fig. 4. Fig. 4a shows a circular element which could be a steel ring or the end of a right cylindrical tube. Assume that the points of the circle that cross the vertical axis are angularly fixed to this line; that is, there is no relative angular motion at these points.

Now, superimpose a sine-wave form of two wavelengths per circumference on this circle so that the nodes of the wave cross the circle at the intersection of the 45 deg radial lines and the circle, Fig. 4b. In the developed view, this arrangement appears as a standard sine wave about a neutral line. The sine wave has a peak amplitude *d*.

Deflection of the circle in this manner will produce an elliptoidal shape *B*. From the principle of arcuation, points *a* will no longer lie at the 45 deg radial lines but are displaced to points *a*₁. Also, chordal length *s*₁ is now somewhat shorter than *s*. This result is, of course, based on the assumption that the center of the arc is still on the vertical axis.

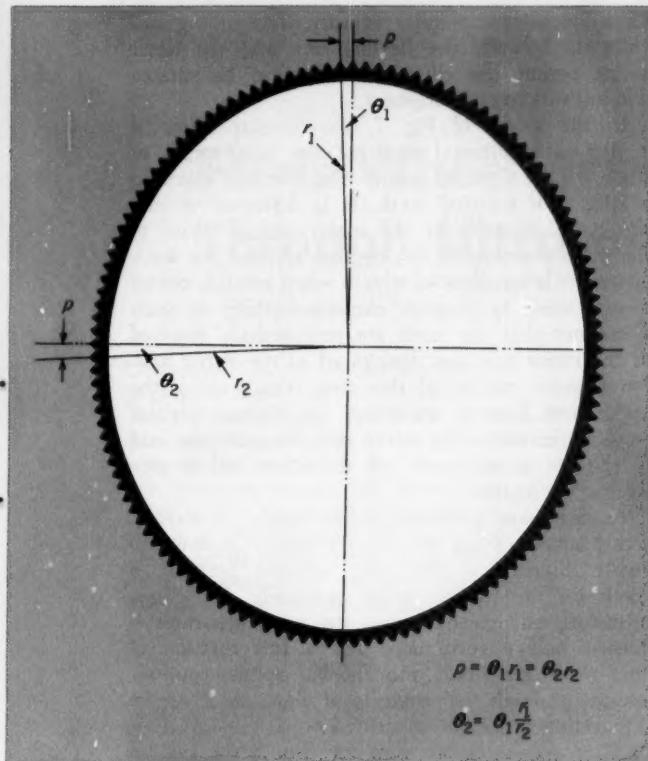


Fig. 5—Conversion of circular element of Fig. 4 into a toothed member. Controlled deflection of this ring causes movement of a point on the teeth and permits power transmission. Equations define basic motion relationships.

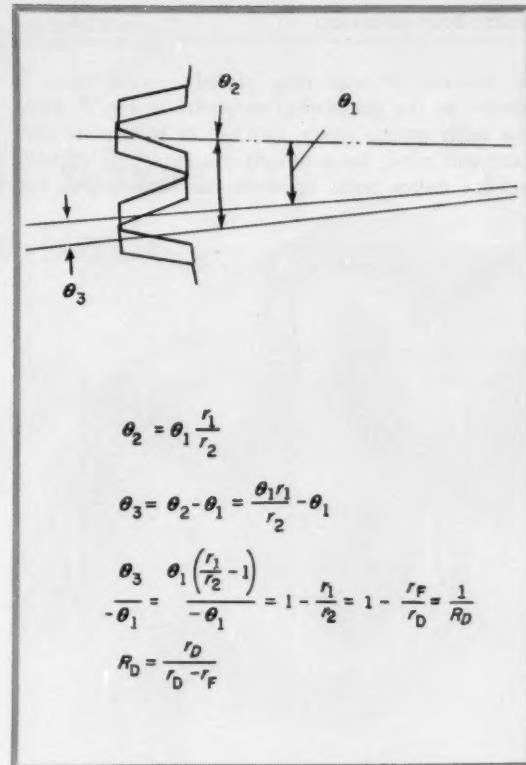


Fig. 6—Tooth-motion relationships for toothed ring in Fig. 5, where R_D = ratio of angular velocity of elliptoid shape to angular velocity of driven point, $r_1 = r_F$ = radius to fixed point, and $r_3 = r_D$ = radius to driven point.

If the sine wave is advanced 180 wave deg, the elliptoidal shape will have its major axis horizontal, as shown by shape C, Fig. 4c. Since the curvature of the arc is decreased, points a become a_2 . Chordal length s_2 is now greater than s .

In the progression of the wave through 180 deg, point a_1 has moved to position a_2 . The distance moved can be calculated and is half of the peak to peak amplitude of the wave, or $d/2$. A 180 deg progression of the wave is equivalent to a 90-deg rotation of the shape. This rotation is produced by deflection only, and not by rotation, of the shape envelope which remains stationary with respect to the vertical axis.

From this analysis, an important fact becomes apparent. Points at the intersection of the vertical axis with the periphery have remained in the same angular position. But points a have moved angularly, with the angular motion on one side being equal, but opposite in direction, to the angular motion on the opposite side.

If the original circle is now converted into a toothed member, Fig. 5, there must be an equal number of teeth in each quadrant even when the ring is deflected into an elliptoid. The reason is that when the ring is deflected the points of the periphery on the major axis will remain on the major axis and the points of the periphery on the

minor axis will remain on the minor axis. Hence, for a 360-tooth ring there will be exactly 90 teeth between the intersection with the major axis and the intersection with the minor axis. If the major axis intersects the center of a tooth, the minor axis will, of necessity, also intersect the center of a tooth.

Assume now that the major and minor axes are rotated so that the major axis intersects the center of the next tooth. Based on the preceding analysis, the minor axis must also intersect the center of a tooth. However, it is obvious that the distance, p , between centers of the teeth is equal. Since the major axis is larger than the minor axis, this automatically means that θ_1 cannot be the same as θ_2 , as shown by the equations in Fig. 5. Since the major and minor axes are rotated through an angle θ_1 , and the minor axis ends up on the center of a tooth even though there is a difference between angles θ_1 and θ_2 , the tooth must have moved during the rotation.

This motion is illustrated in Fig. 6. The position to which the teeth have moved during rotation θ_1 is indicated by angle θ_3 . Here, it can be seen that θ_3 is equal to the difference between θ_2 and θ_1 . The ratio between the rotation of the shape and the angular motion of the tooth is given by the equations in Fig. 6.

The various relationships of these teeth to those

in another circular ring placed around them is shown by the demonstration model in Fig. 7. Here, the teeth at the major axis are in full spline contact and must be angularly stationary. The teeth at the minor axis, however, are disengaged and

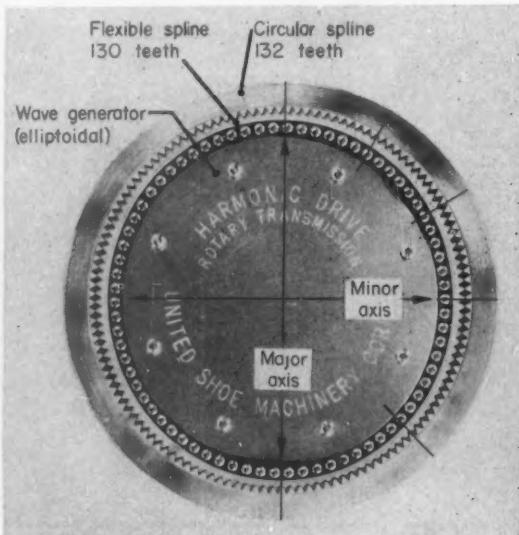


Fig. 7—Basic elements of simple Harmonic Drive. Rotation of elliptoidal wave generator causes flexible spline to counter-rotate.

have the highest angular velocity. The rolling ball elements between the flexible ring and the inner shape permit the elliptoidal shape to be rotated without rotating its periphery.

In the model of Fig. 7, the circular spline is a ring with internal teeth of the same pitch as those of the flexible spline. The flexible spline is a ring with external teeth. It is deflected so that the pitch diameter at the major axis is equal to the pitch diameter of the circular spline. The wave generator is an elliptoid which, when rotated, causes a sine wave to progress circumferentially in such a manner that the teeth are progressively engaged at the major axis and disengaged at the minor axis. No angular motion of this ring occurs along the major axis. Due to arcuation, the highest angular velocity occurs at the minor axis, because one end of the arc is anchored and the other end is producing the motion.

As the wave generator in the model is rotated, tooth action causes the flexible spline to counter-rotate. Starting at the fully engaged position, a tooth on the flexible spline gradually disengages, advances, and re-engages as the wave generator is turned half a revolution. For a full rotation of the wave generator, the flexible spline counter-rotates through an angle equivalent to 2 of its 130 teeth giving a 65:1 reduction ratio.

The cross-sectional view of the drive, Fig. 8, shows how this motion can be put to use. Here the flexible spline is attached to a device using the principles of integration. Since this element is connected to the output shaft, the angular velocities of the entire flexible spline, varying from zero at the major axis to a maximum at the minor axis, are integrated into a constant angular-velocity output. In the previous discussion of the ratio between the rotation of the shape and the angular motion of the tooth (Fig. 6), only the ratio, R_D , to the driven point was considered. The integrated ratio, R_I , where a sine wave is used for the change in curvature, is defined mathematically in Fig. 8.

This motion can also be analyzed by studying the displacement of particles in a traveling wave. Consider the condition of a sine wave superimposed on a circle. As this wave travels circumferentially, it produces angular displacement of circumferential points. In essence, when a transverse wave of radial amplitude and circumferential progression is generated, it produces a longitudinal wave having circumferential displacement as well as circumferential progression. The actual motion of peripheral points with respect to these waves can be readily plotted and studied for various wave conditions and motion combinations.

ACKNOWLEDGMENT

This article is based on a paper presented at the Sixth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 10-11, 1960.

Copies of *Transactions of the Sixth Conference on Mechanisms* (152 pages), containing the 16 papers presented, are available at \$2.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

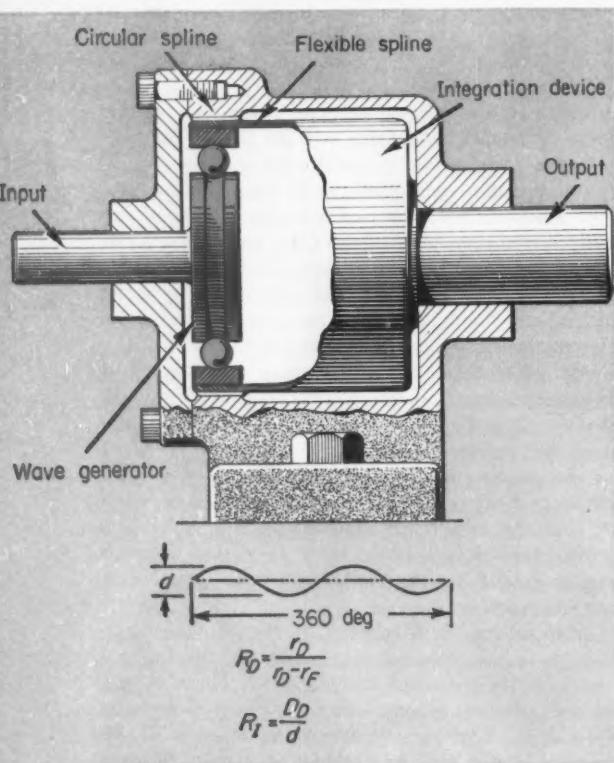
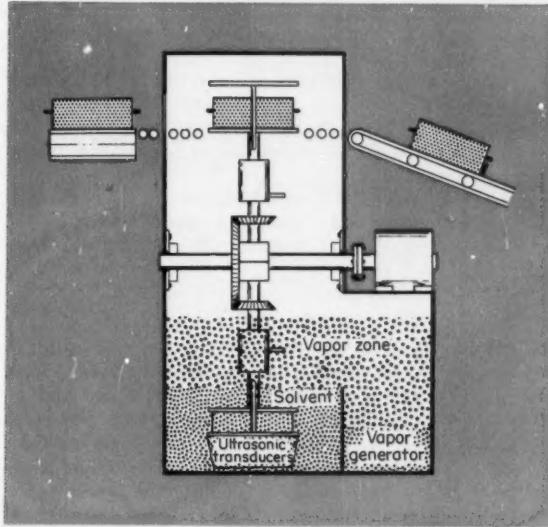
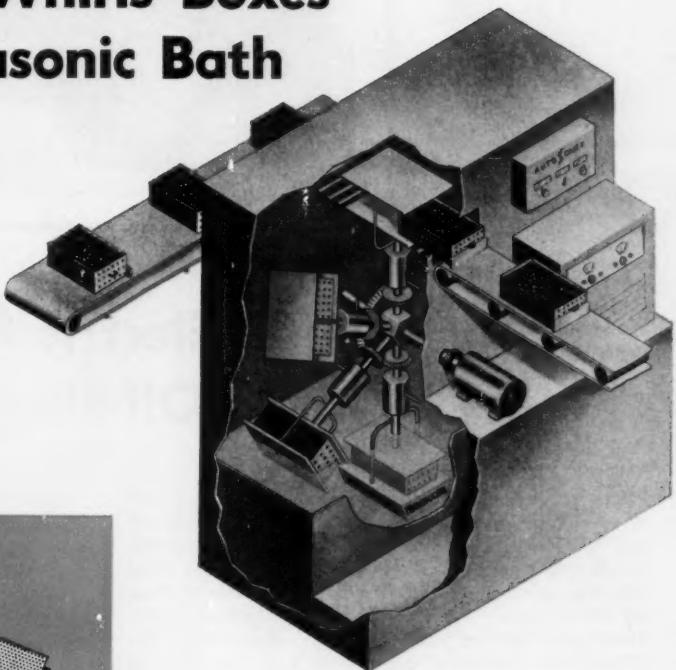


Fig. 8—Arrangement of principal operating elements in simple Harmonic Drive design.

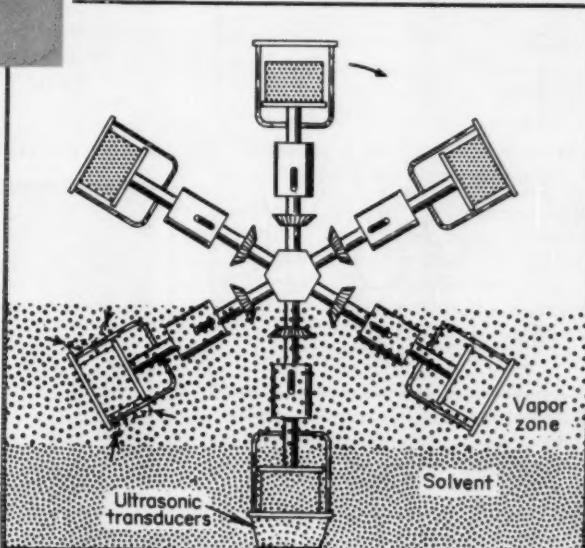
Ferris-Wheel Whirls Boxes Through Ultrasonic Bath

CONTINUOUS line of tote boxes containing small parts moves through a washing device that seizes them, turns them upside down, and immerses them in an ultrasonic bath—then replaces each in the moving line. Tote boxes and contents are degreased together without human intervention for unpacking or manipulation. The ferris-wheel dunker has six loading stations which clamp the boxes hydraulically and whirl them as they are lowered into the cleaning solution.



PLANETARY bevel gears give the box a whirl as it enters the cleaning solvent. Chips and scraps are shaken out by the motion. Cleaning is completed by the ultrasonic wave generator in the bottom of the bath.

EMPTY loading station receives a box of parts from the conveyor belt. A lever pushes the degreased box onto the rollers beyond the station. Spring-loaded platform presses the box securely against the cover plate. Rod projecting through the spring housing locks the platform by engaging a dog at the top of the slot. Cam disengages the platform lock at the end of the cycle.



ULTRASONIC tote box cleaner was developed by AutoSonics Inc., Philadelphia.



Diesel-Electric Powerplant Drives Off-the-Road Hauler

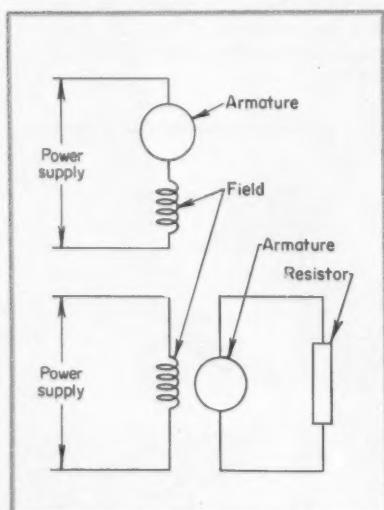
PROTOTYPE diesel-electric off-the-road dump truck can haul 55 tons of payload. The production model is expected to haul 120 tons, even with a slight reduction of the present vehicle weight of 58½ tons. Power is from a 630-hp diesel engine generator set, but wheel motors are capable of drawing 450 hp apiece. Wheel reserve capacity therefore permits use of higher-powered plants as they become available. Developers have mentioned two possible sources of increased power: Trolley lines on mining runs with the truck operating like a trackless trolley, and a gas-turbine powerplant.

Operator controls were designed to be as conventional as possible. A driver needs less than eight hours to check out on the new truck. Ride on the four big wheels proved

to be bouncy, but much softer than in conventional trucks. Dynamic brakes satisfied the operators. They used them almost exclusively, applying conventional brakes only for stopping and holding.

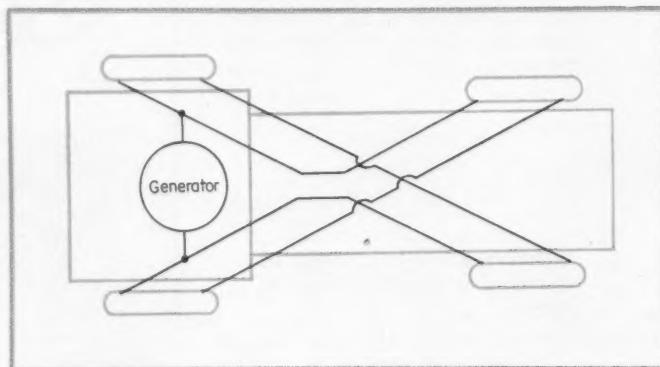
Kingpin steering allows the big truck to turn in a shorter radius than conventional 15-ton trucks. Relays for motor control are mounted in the box below the kingpin. An important goal of the design was accessibility of major components.

The big truck, called "Lectra Haul" was developed by Unit Rig and Equipment Co., Tulsa, Oklahoma. It uses motorized wheels developed by General Electric's Locomotive Div., Erie, Pa.



DYNAMIC BRAKING is accomplished by using wheel motors as generators and dissipating power through an air-cooled resistor.

SERIES-CONNECTED motor pairs are connected to the generator in parallel. Voltage for a given speed is half that required if all motors were in series. On the other hand, starting-current demands are half as much as if all motors were connected in parallel. With motors in series only, a slipping wheel would go faster, cutting off current from other motors and possibly stalling the vehicle. In an all-parallel hook-up, a slipping wheel would shift its share of generator power to the other wheels. In the compromise circuit that is used, a slipping wheel robs its mate of current, but the ineffectual pair will shift power to the other pair and maintain total vehicle traction in most cases. Pairs in series are located diagonally—that is, right front with left rear, left front with right rear.



ENGINE
GENERATOR
WHEELS
TIRES
STEERING

Cummins VT-12-B1; 700 hp @ 2100 rpm
General Electric GT-594; input 630 hp
General Electric GEZ 5319 Electric Wheels
37.5 x 33-42 tubeless
Hydraulic-powered kingpin steering with positive feedback

BRAKES

Electro-dynamic working brakes; Goodyear Industrial Disc Brakes for parking and emergency
35 yd struck, 40 yd heaped; max payload wt 55 T

CAPACITY

AXLE WEIGHT

Front
Rear

WHEEL BASE

22 ft 4 in.

LENGTH

Overall; 42 ft 7 in.

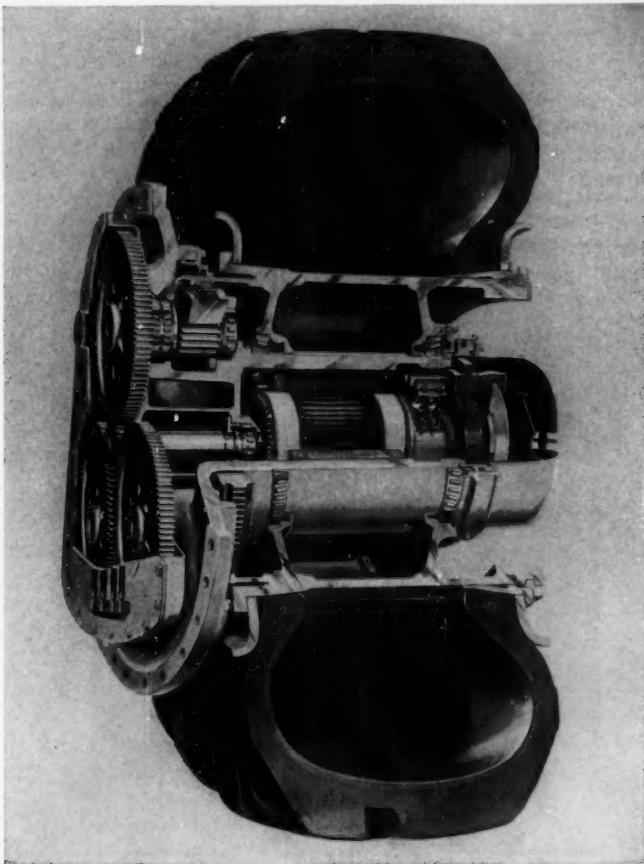
WIDTH

Overall; 14 ft 0 in.

HEIGHT

Overall; 14 ft 4 in.

design in action



TRACTION for the giant hauler is provided by GE's Electric Wheel. Weight saving that made the wheel feasible was accomplished by using a single piece that serves as magnet frame and a load-carrying member. It is also a gear box for the transmission and is flanged for bolting to the vehicle body. The gear train resembles a planetary system, except that "planets" are fixed to the housing and do not revolve around the sun. This system was chosen because torque transmitted by the high-powered motor at low speeds called for an excessively wide tooth face if the load was to be borne by a single gear. The ring gear is flexible enough to deflect and create equal loading on all three planetary pinions. Although dynamic braking (using the motor in reverse as a generator) serves most driving needs, a hydraulically operated disc brake is provided at the outer end of the hub for parking and emergencies.

CONVENTIONAL controls cut break-in time for new drivers.

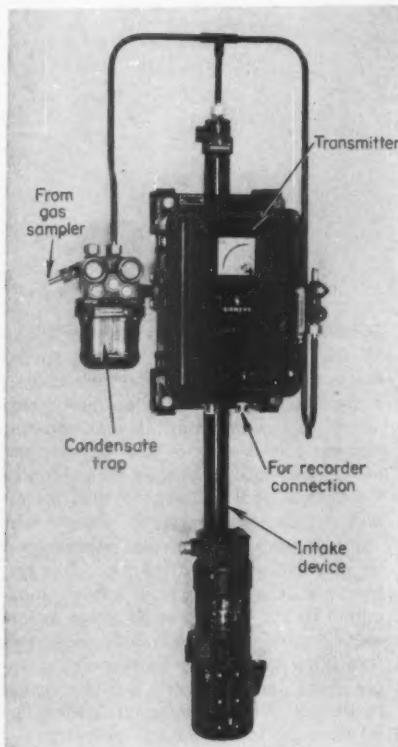
Shifting with the normal-appearing shift lever does not require tachometer watching or double clutching. Shifting from low to high range cuts out rear-wheel motors and drive is through front wheels connected in parallel.

Foot accelerator provides the normal function of throttling the diesel engine.

Brake pedal is similar to accelerator in appearance. It performs three functions: 1. It switches motor circuits to braking configuration. 2. It varies resistance in the resistor connected across the armature. 3. It speeds up the engine through cross-connection with throttle linkage.

Steering wheel, although conventional in appearance, operates a unique hydraulic steering system with positive feedback.

Hydraulic emergency brake is operated by the lever to the right of the driver.



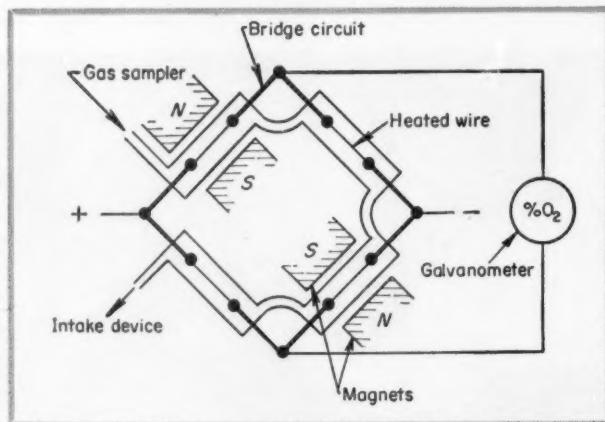
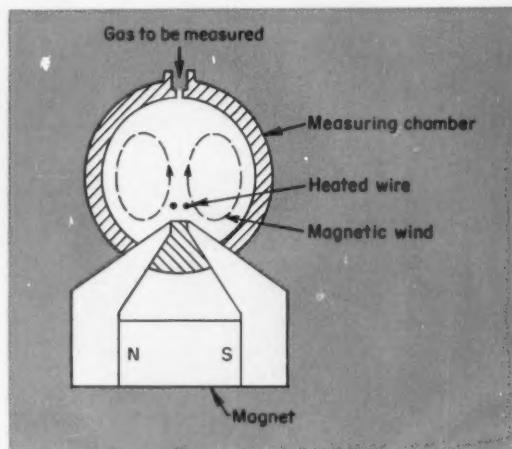
OXYGEN DETECTOR is a product of Siemens & Halske AG, Munich, Germany.

ECCENTRIC location of magnet tips in a test chamber made of nonmagnetic material produces a nonsymmetrical magnetic field within the chamber. Wire resistors passing through the strongest part of the magnetic field are heated by an electric current. Oxygen, affected by the magnetic field, causes a turbulence in the stream of gas, cooling the wires enough to lower their resistance.

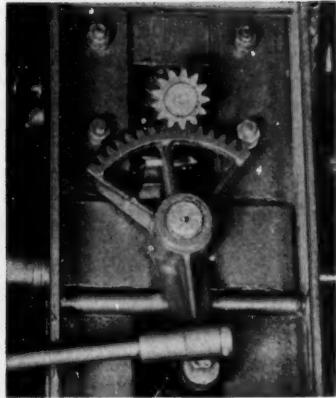
A WHEATSTONE BRIDGE is constructed of four gas-sampling units—two have magnets as described above, the other two (controls) have only the chamber and heated wires. The bridge is balanced with a known nonmagnetic gas. Cooling due to magnetic wind unbalances the bridge. The galvanometer is calibrated directly in per cent of oxygen.

Magnetic Wind Detects Oxygen Fractions

OXYGEN is unique among technically important gases in having magnetic permeability greater than 1. All others exhibit values equal to or lower than 1 (Permeability of a vacuum is established as 1). A new oxygen meter performs a nondestructive test for oxygen by subjecting the unknown gas to a magnetic field. Motion of oxygen molecules causes a "wind." Strength of the wind is proportional to the oxygen fraction present.

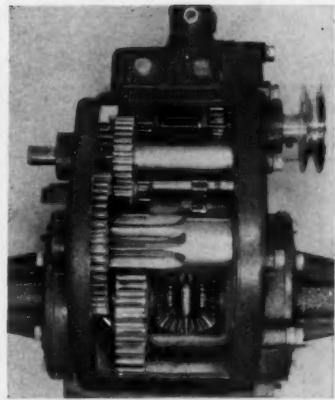


Double-Duty Controls Simplify Garden Compact

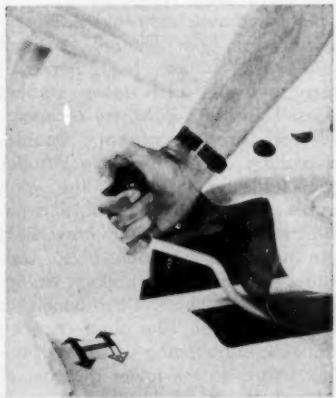


GEARS in the steering linkage are used in as-cast condition. Spur gear and segment are shell molded of pearlitic malleable iron. Draft angle of casting produces the bevel in the gear teeth needed to compensate for pitch of steering column.

MARK 1 suburban tractor gets a lot of performance from comparatively few parts. Appearance is free of detail, but designers avoided a "stripped-down" look. A 5½-hp Briggs and Stratton air-cooled engine delivers power through a V-belt. Automotive-type transmission is close-coupled to the rear axle, giving a total available reduction of 120 to 1. Multiple-function controls cut down the number of necessary levers and knobs. Gear reduction of 4 to 1 in the steering linkage makes the tractor heading easy to hold, even on pitching ground. Mark 1 is a product of Porter Cable Machine Co., Gasoline Products Div., Syracuse, N. Y.



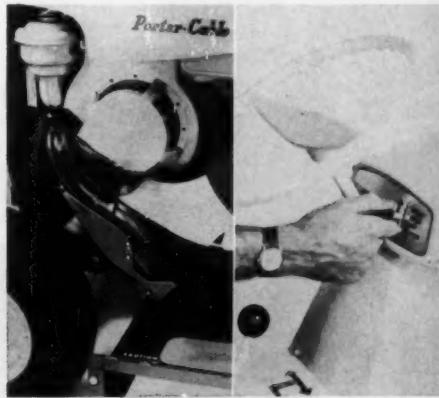
TRANSMISSION is housed with the differential on the rear axle, adding weight to the vehicle's drive wheels. Gears run in a bath of oil. A magnetic drain plug traps metal particles.



CENTER-MOUNTED gearshift lever follows standard manual-shift pattern rotated 90 degrees to compensate for cross-mounted transmission.



CENTER-PIVOTED front axle accommodates the tractor to changing landscape contours.



DUAL-PURPOSE controls combine functions logically: Foot pedal functions as brake and clutch; hand lever controls choke and throttle.

Turbine-Powered Hydraulics Raise Ladder

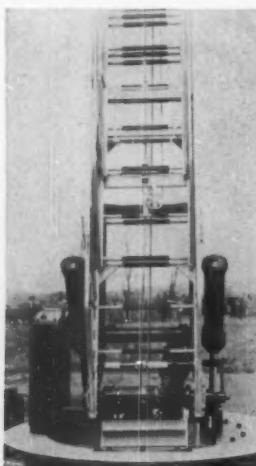
in Seconds



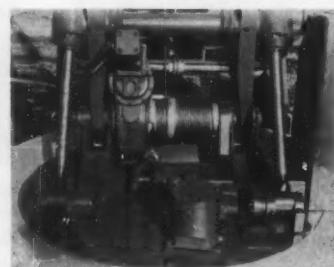
POSITIONING the fire ladder calls for three basic motions—elevation, extension, and rotation. It takes 25 sec to elevate and extend a 100-ft ladder. The turntable makes one rotation per minute.



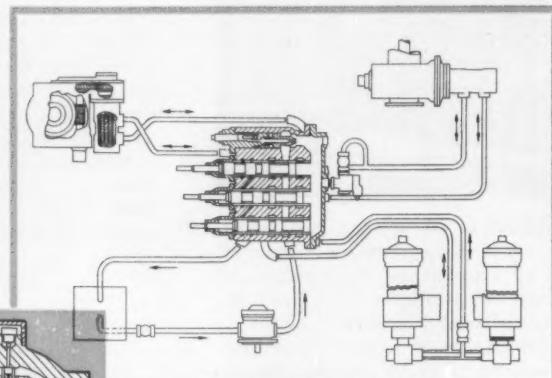
CYLINDERS raise and lower the ladder. Extension and rotation are produced by hydraulic motors driving windlass and turntable through reduction gearing.



PISTONS are anchored to the turntable and conduct counterflowing streams of hydraulic fluid in their shanks. This eliminates flexible hose. Two dynamic couplings are required at the foot of each piston.



GAS-TURBINE fire truck takes 25 sec to raise its 100-ft ladder to 85-deg elevation. Allowing for 90-deg rotation of the turntable, the ladder can be laid against a 9th-story window 40 seconds after the truck arrives. It's done with a hydraulic system that takes power from the 330-hp gas-turbine engine. Irreversible transmissions keep the ladder from drifting when mechanical locks are not used—for instance when the ladder is used as a water tower and repositioning is frequent. A special retraction relief valve limits pressure used in retracting the ladder to avoid breaking a lock if it is left on. Truck was developed by American LaFrance, Elmira, N. Y.



HELICAL-flight hydraulic motors replace previously used spur-gear motors. DeLaval Steam Turbine Co., Trenton, N. J., maker of the motors, says they offer lower starting torque, smoothness and quietness of operation, and more accurate control. Double-reduction gearing on the turntable includes a spur-gear stage and a worm. The worm is irreversible and gives the turntable its no-drift characteristics. A similar irreversible worm is in the ladder-extension drive. Ladder-elevation cylinders are double acting. Fluid flows through concentric channels in the hollow piston rod. The outer channel, an annular hole surrounding the inner channel, conducts fluid to the lower chamber of the cylinder to lower the ladder. A series of holes in the piston wall distributes the fluid in the chamber. The inner channel, a pipe running through the center of the outer channel, delivers fluid to the upper chamber.

Traverse Meter Uses Gyroscope Sensor

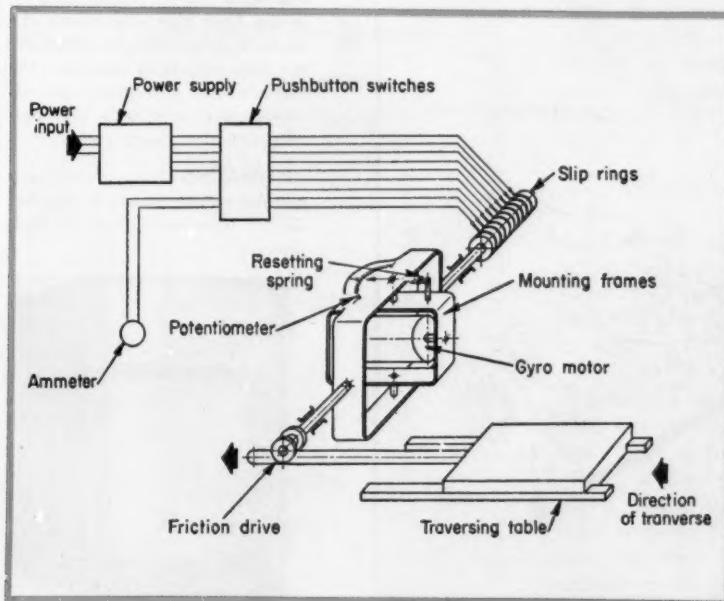
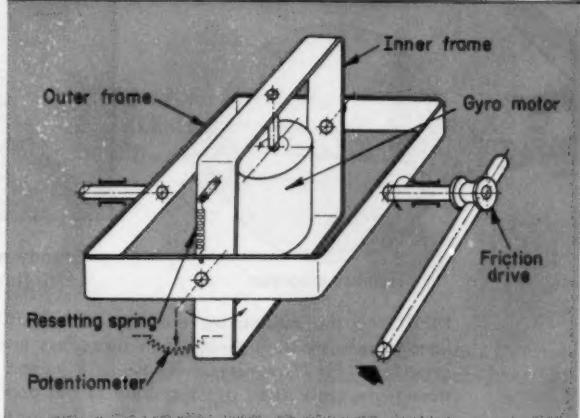
LINEAR SPEED of a moving platform (e.g., machine-tool traversing table) is accurately measured by precession of a gyroscope. The instrument not only detects, but accurately measures linear speeds as low as 0.004 in. per min.

LINEAR MOTION is changed to rotary by a push-rod running against a wheel coupled to the outer mounting frame of the gyroscope. Precession of the gyroscope, proportional to angular speed of the outer frame, is sensed by the potentiometer. The resetting spring restores the gyro to zero position when the motion has stopped.

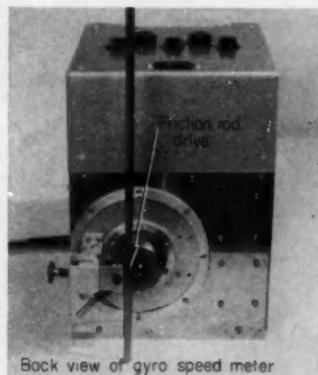
PUSHBUTTONS provide four ranges of speed metering by changing winding connections on the rotor's synchronous motor. Ammeter connected with the potentiometer is calibrated in mm per sec.



Gyro Speed meter

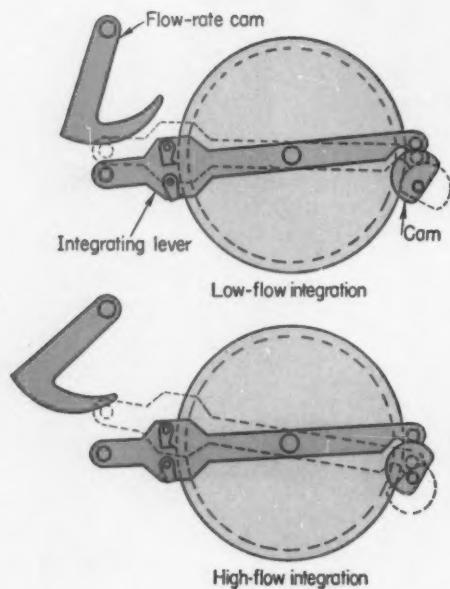


GYROSCOPIC speed meter was designed by Ingenieurbuero Boelkow, Ottobrunn Bei Muenchen, Germany.

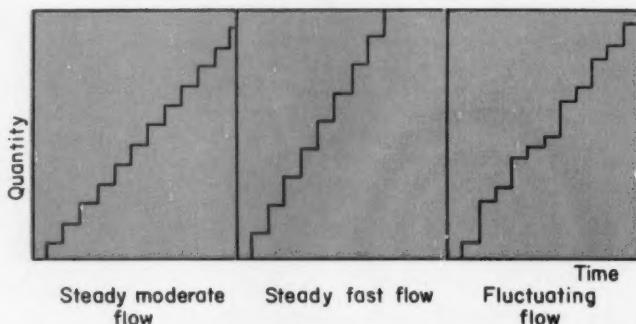


Back view of gyro speed meter

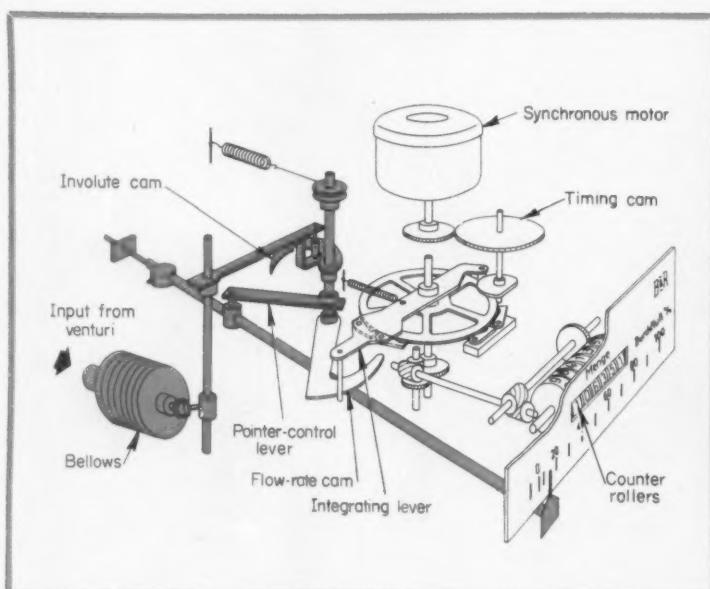
Step Integrator Keeps Running Total for Flowmeter



TIMED alternation of reading and adding makes the integration curve of a mechanical integrator look like a series of small steps. It takes an instantaneous reading of flow rate and applies it to a measured period of time. Then it takes another reading and applies it to the next measured period of time. Since time intervals are sufficiently small, a good approximation of total flow is reached.

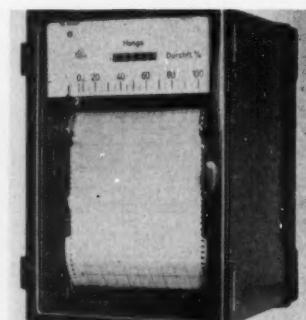


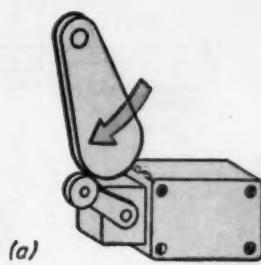
INPUTS to the mechanism are flow rate (left-hand cam) and time (right-hand cam). Continuously rotating timing cam drops the integrating lever periodically to read flow rate from the flow-rate cam. Return motion of the lever, indicating flow for one timing-cam revolution, is transmitted to the gear by escapement dogs. Length of return motion depends on the position of the flow-rate cam.



PRESSURE from a venturi section in the flow being measured operates a small bellows to actuate the flow-indicating linkage. The involute cam straightens out rotary motion in a way that permits use of a linear scale.

INTEGRATING flow meter was developed by Bopp & Reuther GmbH, Mannheim-Waldhof, Germany.





(a)



(b)

Fig. 20 — Recommended arrangement and contour of rotary operating devices for roller-lever switch, *a*, and roller-plunger switch, *b*.

a design guide

precision snap-action switches

R. C. FROELICH and

E. E. LEIRD

Micro Switch
Div. of Minneapolis-Honeywell Regulator Co.
Freeport, Ill.

Part 2

Mechanical Requirements

- Actuating Motion
- Operating Speed
- Operating Travel
- Operating Forces

Electrical Requirements

- Circuitry
- Load

Reliability

- Repeatability
- Life

MECHANICALLY actuated, precision snap-action switches perform important functions as control devices in electrical circuits. Such applications usually demand satisfactory operation for extended periods of time. This article, which concludes a two-part series, examines the mechanical and electrical requirements of precision switches. Proper matching of both these factors to the application helps assure life and reliability for which a particular switch is designed.

Mechanical Requirements

Of concern here are forces and types of motion which provide proper switch application. Recommendations and illustrations of switch types aid in matching the operating device to the switch and its actuator.

Actuating Motion: Precision switches are available with built-in actuators designed to handle virtually every type of motion and operating condition. Actuating motion may be rotary, as obtained from rotating devices such as cams, or linear, as obtained from reciprocating devices such as slides and piston rods. However, faulty application of the operating motion to the switch actuator is the major cause of

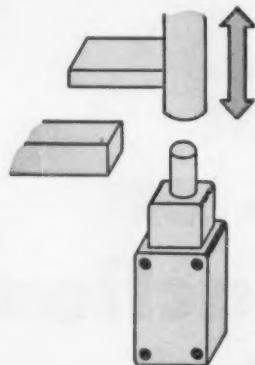


Fig. 21—Push-plunger switch in application where overtravel is limited.



Fig. 22—Switch with hinged-type actuator for use with overriding cam.

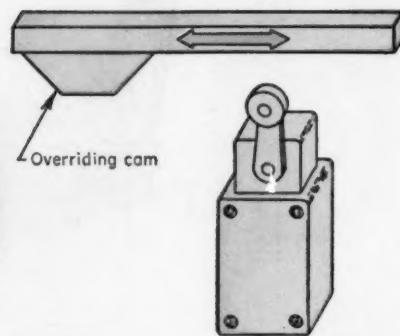


Fig. 23—Proper switch position for two-way overriding cam.

premature mechanical switch failure.

Rotary Motion: Because a rotating device imparts a degree of side thrust on a switch actuator, lever-operated switches with rollers (Table 1, Part 1) are generally used for such applications. The switch lever should be positioned as nearly parallel with the leading edge of the operating cam as possible. Operating force should be in the direction of lever rotation and perpendicular to the shaft axis about which the lever rotates, Fig. 20a.

If movement characteristics must be closely held, Table 3, or if available space does not permit the swing of a lever, roller-plunger switches (Table 1, Part 1) may be used. Because of side thrust, inclined cams should be used with roller-plunger actuators. Cam rise should not exceed 30 deg, Fig. 20b.

Linear Motion: If a cam or a dog is used as the actuating means on a linearly driven member, an element of side thrust is again present. Consequently,

the considerations and switch types for rotary-motion actuation also apply for linear-motion actuation. However, where overtravel can be closely controlled, a straight push-plunger switch (Table 1, Part 1) can be installed at the end of the moving part, Fig. 21. Actuating force should be applied as nearly as possible in line with the plunger axis to prevent side thrust from increasing wear or causing breakage of the steel shaft or supporting members.

Linear cams which override a switch often pass back over the switch on a return stroke. Switches with one-way actuators provide no electrical contact on the return stroke. Simple built-in adjustments in some types of lever-operated switches permit electrical operation only when the lever is moved clockwise, or counterclockwise, or in both directions, Fig. 12b, Part 1. Other types which have hinged actuators that pivot away from the returning cam, Fig. 22, also eliminate the need for building hinged dogs

Table 3—Typical Operating Characteristics of Precision Switches

Switch Type*	Actuator Style	Operating Force (oz)	Releasing Force (oz)	Pretravel (in.)	Overtravel (in.)	Movement Differential (in.)
Basic switch	Push plunger	7—13	4	0.012	0.005	0.002—0.002
	Roller plunger	9—13	4	0.015	0.140	0.004—0.002
	Roller lever	3½—6	¾—1½	0.125—0.250	0.094—0.156	0.003—0.040
Subminiature switch	Push plunger	3—5	1	0.030	0.005	0.004
	Roller lever	1—10	2—4	0.078—0.219	0.015—0.030	0.015—0.030
Enclosed switch	Push plunger	9—24	4	0.015—0.078	0.219	0.002
	Roller plunger	9—13	4	0.015	0.140	0.002
	Roller lever	10—20	6	0.188	0.219	0.006
Limit switch	Push plunger	6 (lb)	2 lb	0.065	0.250	0.020
	Roller plunger	6 (lb)	2 lb	0.065	0.219	0.020
	Roller lever	3 (lb)	8	20 deg	30 deg	12 deg

*See Table 1 in Part 1 for description of switch types.
Min-max figures may represent the variation in a single switch or the range available in similar switch types.

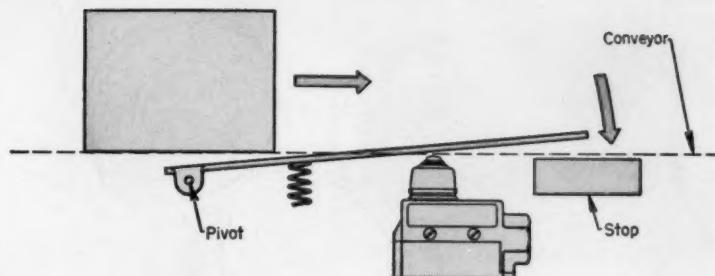


Fig. 24—Acceptable arrangement for using standard switch to detect varying-sized objects on conveyor.

into a machine.

With two-way cams, the switch lever-actuator should be positioned as nearly perpendicular to the actuating force as possible so that no force component is applied to the actuating shaft from either direction, Fig. 23.

Variable or Multidirection Motion: Frequently, an electromechanical switch must detect large or irregularly shaped moving articles such as found on conveyors. Direction of operating motion often varies, obviating the use of a lever or plunger-actuated switch. Distance from object to switch can vary and thus subject the switch to different degrees of movement. A common solution is to let the weight or pressure of the moving piece operate a spring-loaded paddle which is equipped with an overtravel stop, Fig. 24. In this manner, controlled motion is available for actuating the switch.

Similar problems are presented by items being processed or machined. Such pieces, used as the switch-actuating means, may also change in size, shape, or position from one run to the next. In these applications the best procedure, if possible, is to have some well-mounted part of the machine actuate the switch.

When it is essential that the switch be actuated directly by a variable-motion device, a coil-spring actuator should be used, Fig. 25. These flexible actuators accept operating motion from any direction. However, bending the spring too severely and allowing it to snap back freely may result in an occasional re-actuation of the switch and reduced flexure life for the spring.

Other types of actuators which may be used for detecting lightweight, irregularly shaped objects are shown in Fig. 26. However, if an extra-long actuator is required, only switches specifically designed for them should be used, Fig. 27. When an extra-long actuator is used, the switch should be mounted upside-down and vertically so the weight of the actuator does not trip the switch or prevent the internal spring from resetting the switch.

Operating Speed: Because of increased operating

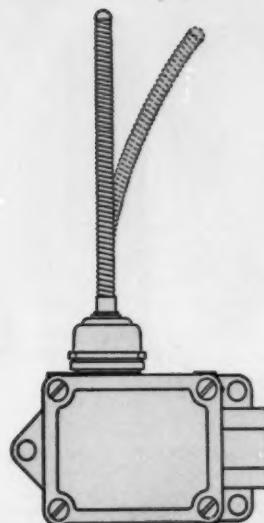
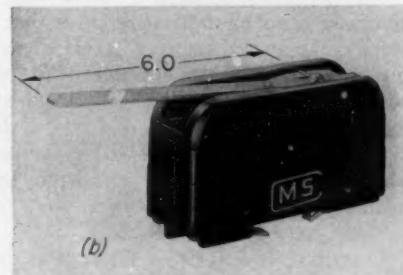


Fig. 25—Precision switch with flexible coil-spring actuator.



(a)



(b)

Fig. 26—Aluminum-rod actuator for limit switch, a, and steel-lever actuator for basic switch b.

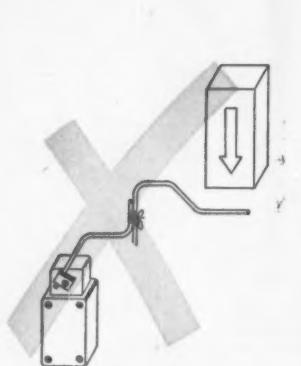


Fig. 27—Two examples of improper switch application as a result of attachment of supplementary actuators.

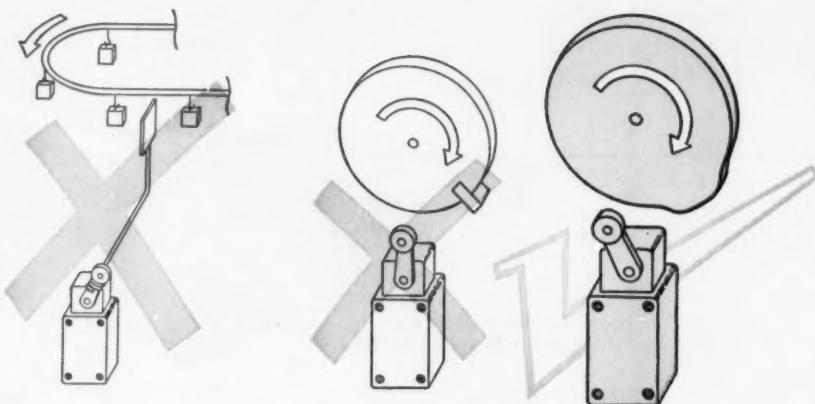


Fig. 28—Reducing shock to switch actuator with improved profile of fast-operating cam.

speeds, impact forces at the first instant of mechanical contact become critically important. Two factors to consider in minimizing stress are: 1. Mass of switch lever and roller. 2. Profile design of operating cam.

Size and weight of roller and lever should be kept low to reduce inertial stress at impact. The belief that large, heavy limit switches give longer life is not necessarily true. Smaller switches, properly designed and applied, have many times the mechanical life of heavier switches. Some switch types use nylon rollers to reduce mass. Also, forged-aluminum lever arms reduce weight without sacrificing strength.

Cams should be carefully inclined to insure smooth acceleration of the switch actuator. The shallower the cam rise, the less the impact delivered to the roller, Fig. 28. Likewise, a cam with a tapered trailing edge reduces shock to the switch actuator and extends its life.

Repetitive operation is also related to operating speed. Depending on the type of unit, precision switches snap from normal to operated condition in from 0.003 to 0.005 sec. With a small electrical load, certain types of switches operate up to 1800 cycles per min. On full rated load, heating by the arc limits the continuous rate to 150 operations per min.

Another point to keep in mind when designing actuating cams for fast operation is that, while precision snap-action switches transfer circuits almost instantly no matter what the speed of actuation, about one-fifth second is usually required to operate a relay, solenoid valve, or other related device. Thus, cam rise should have a dwell of sufficient length for a momentary-contact switch to operate such auxiliary devices, Fig. 29.

Operating Travel: Excess linear or angular travel of the switch actuator can damage or greatly reduce the mechanical life of a switch. Also, certain portions of actuator travel are more critical for some switch

types than others. Details of operating travel are outlined here; a basic explanation of terms and travel positions is given in *Definitions* in Part 1.

Pretravel: On equipment which has a wide range of movement or continuous motion, such as conveyors, pretravel is seldom important. However, in precise operations, such as limit-stop work, pretravel becomes critical. As shown in Table 3, push-plunger or roller-plunger switches provide the most sensitive pretravel characteristics. Roller-lever switches can be held in continuous contact with the operating cam to reduce effective pretravel, but this method is generally not satisfactory because of wear on the roller mechanism.

Where highly sensitive operation is required, as with pressure or temperature-sensing elements or sorting and gaging devices, standard plastic-case basic switches offer minimum pretravel, Fig. 30. Such switches may need to be mounted in suitable enclosures and protected by relays from heavy or inconsistent electrical loads.

Overtravel: Because of the strain imposed on the switch assembly, overtravel should be kept to a minimum. Also, internal actuator return springs in switches so equipped experience greater flexure with reduced fatigue life unless overtravel is minimized. However, overtravel should be consistent with possible wear or variations in the moving actuating part, as with motors that coast after power is removed, mechanisms that have strokes which vary with machine load, and devices that are operated by liquid-gas pressure or by thermal elements.

Where switches can be overridden, roller actuators on properly mounted switches permit unlimited overtravel. Lever-actuator switches are available with up to 90 deg overtravel, Fig. 31, but such motion should be used only for emergency or infrequent requirements. Of course, overriding cams should have a gradually tapered trailing edge to prevent the actuator from snapping back.

With push-plunger actuators, overtravel must be

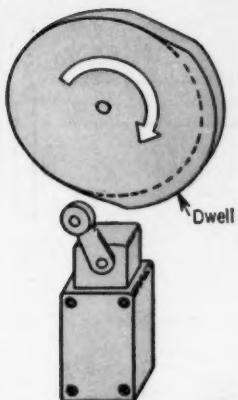


Fig. 29 — High-speed cam with prolonged dwell to provide sufficient energization time for auxiliary electrical devices to operate.



Fig. 30—Basic-switch type which is available with pretravel down to 0.012 in. max.

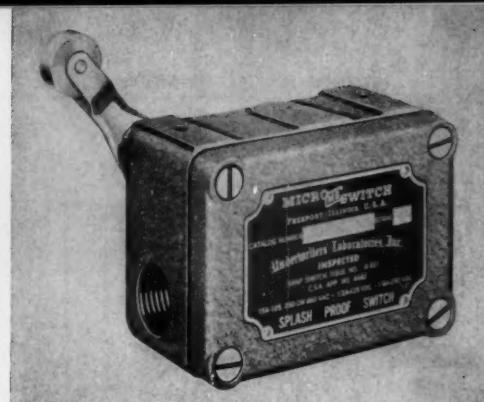


Fig. 31—Splash-proof, roller-lever switch which permits up to 90 deg overtravel.

closely controlled. Most switches, including plastic-case basic types, can safely withstand a static load of 50 lb acting in line with plunger travel. Hence, if operating forces are substantially below 50 lb, no overtravel limit is required to protect the switch from damage.

Where greater motion is required than that offered by the push-plunger basic switch in Table 3, auxiliary actuators can provide additional overtravel, Fig. 32. If extreme overtravel is required, the normal use of the switch can be inverted—that is, by holding the switch actuator depressed, the necessary overtravel can be obtained by moving the operating device away from the switch and allowing the switch actuator to be released completely.

Movement Differential: Also called differential travel, movement differential is determined by contact break distance and electrical load (see Fig. 39 and discussion under *Repeatability*). This increased movement is caused by the slight flexure required in the current-carrying spring before it snaps from one position to the other.

Thus, differential travel can be more important than pretravel in some precise gaging work. Care is required when designing close-differential applications. More movement than the specified switch characteristic should be designed into the mechanism to insure dependable resetting of the contacts in case wear or drift in either (or both) switch or mechanism should vary the operating point. Such emergency travel is also necessary with the overtravel characteristic since differential travel depends on both snapover and snapback points.

The sensitive basic switch mentioned under *Pretravel* provides differential motion on the order of 0.0002 in. Its single-pole double-throw contact arrangement permits sorting or gaging by either applying force to or releasing the switch plunger. Precise indications of size, with or without automatic sorting, can be obtained by using two or more such switches with lamps, relays, or solenoids.

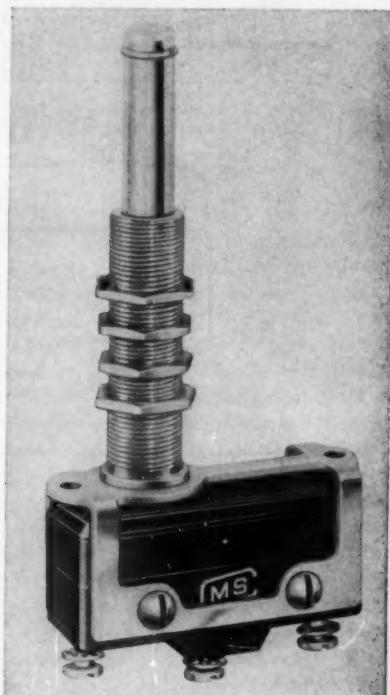


Fig. 32—Typical precision switch with auxiliary actuator for applications requiring extra amounts of overtravel.

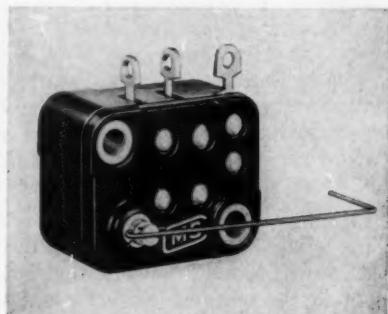


Fig. 33—Special switch with operating torque of 4 gm-in., max, and releasing torque of 0.5 gm-in., min.

PRECISION SNAP-ACTION SWITCHES

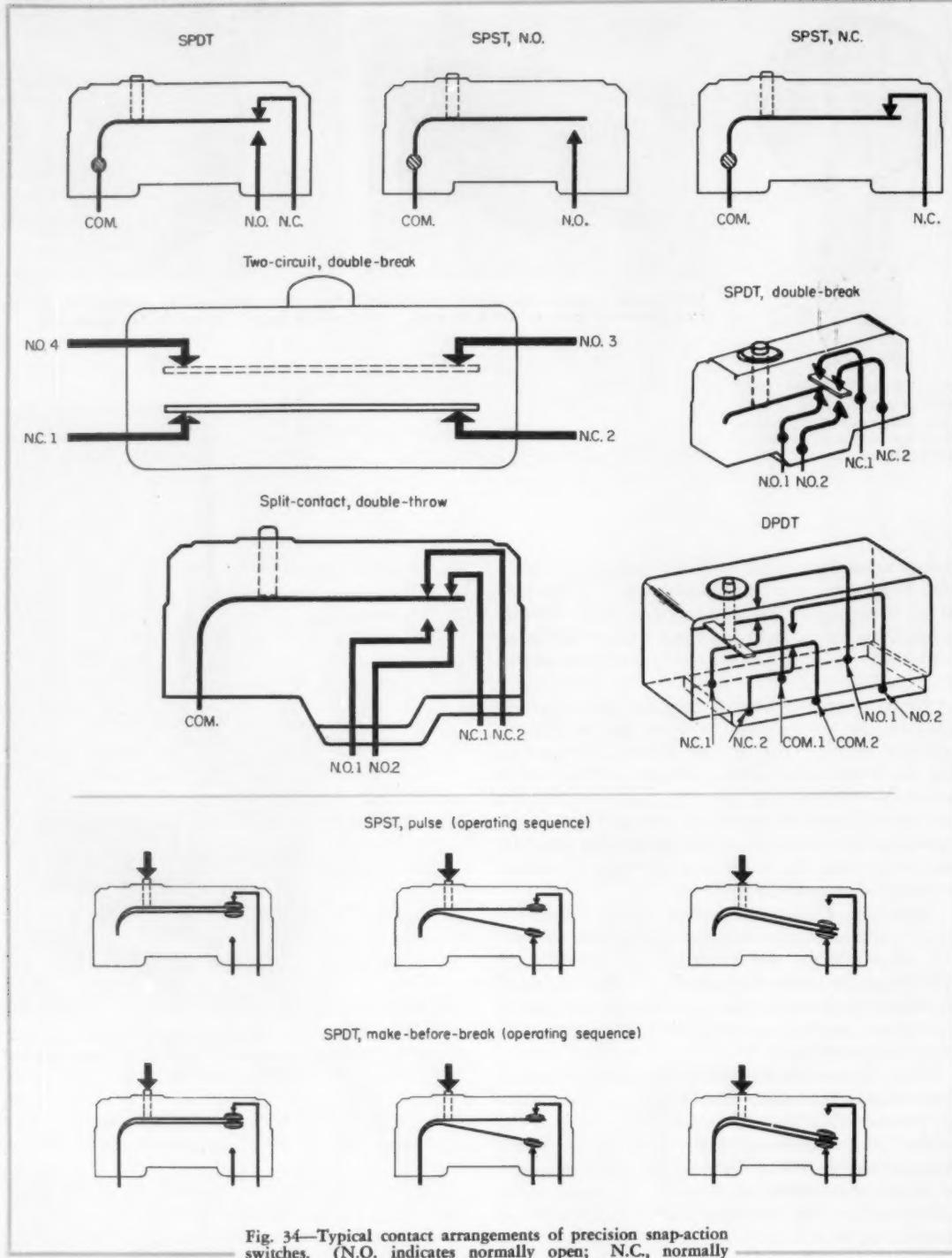


Fig. 34—Typical contact arrangements of precision snap-action switches. (N.O. indicates normally open; N.C., normally closed; COM., common.)

Operating Forces: In a precision switch, operating force is that straight-line force in the direction applied to the actuator to cause the switch contacts to snap to the operated contact position. This force depends on spring stiffness (both in the actuator return spring and the current-carrying spring), contact separation, and the type of seal used.

Most machine applications have ample forces for actuating standard enclosed switches. Applications which call for detection of light-weight or gravity-fed objects, such as counting of small parts, require a switch with a force characteristic measured in ounces. The lever-type switch in Fig. 26a operates at 5 oz and releases at 1 oz. The basic switch in

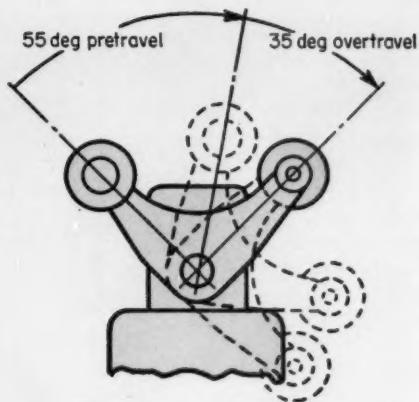


Fig. 35—Maintained-contact limit switch. When yoke actuator is moved 55 deg from either extreme position, it operates the switch and travels another 35 deg to its opposite extreme position. Actuator remains in this position until operation is reversed.

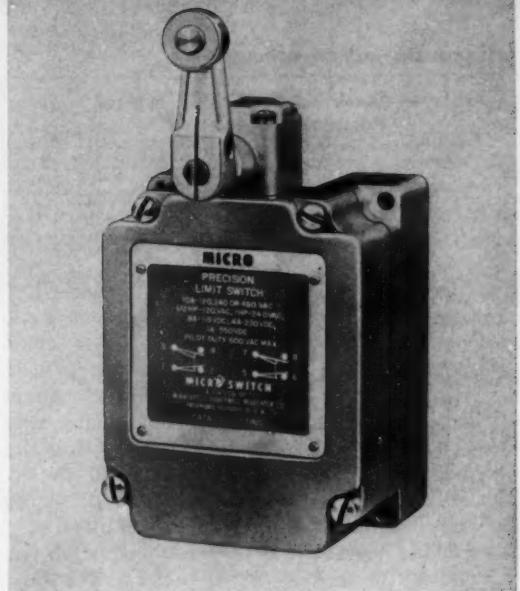


Fig. 36—Center-neutral rotary switch for controlling up to four isolated circuits.

Fig. 26b operates with 1 oz of force and releases at $\frac{1}{8}$ oz. Instrument-type, rotary-actuated switches, Fig. 33, offer the ultimate in precise, sensitive operation for use in coin-operated devices and counting applications.

In measurement and regulating applications, operating forces are closely correlated with movement characteristics, and a small differential between operate and release positions is important. Weights or extensions should not be attached to switch actuators to reduce the required operating force because inability of the return spring to reset the contacts may result in erratic operation. Likewise, the switch actuator should never be expected to return the device which is operating it.

A switch that is subjected to unusual conditions of ice or mud must have an inherently high release force to prevent the actuator from jamming and failing to release the contacts. In such environments, aircraft-type switches should be selected. The compact switch in Fig. 4, Part 1, provides a 5-lb release force and has a scraper ring on the plunger to remove foreign material.

Electrical Requirements

Electrical application of a precision switch involves more than just making the electrical connections. Number of circuits, whether they should be opened or closed by the switch contacts, and use of alternating or direct current may present no problems. However, questions which concern peak loads, arcing and heating, and special contact arrangements become more complicated. Following are factors to consider when electrical specifications are being determined.

Circuitry Design: For this discussion two categories of circuit design are established and clarified:

1. Integral design of electrical switching action within the basic switch.
2. Functional and operational variations provided by the design of the switch or external mechanisms.

Contact Arrangement: Precision switches offer a variety of contact arrangements, Fig. 34. Single-pole single-throw (SPST) and single-pole double-throw (SPDT) switches are suitable for most control applications. However, in more complex equipment, switches having two separate circuits are required. Multiple-circuit switches can usually replace two single-pole switches or eliminate the extra relays which are required to provide circuits that, in turn, are controlled by single-pole switches.

Double-pole double-throw (DPDT) switches simultaneously make and break two independent circuits. A normally open and a normally closed contact for each pole provide several possible wiring combinations with a savings in space and weight.

A make-before-break switch, a SPDT device, provides a momentary overlap of circuits when switching from one position to the other. This feature is useful where circuits must be switched with no interruption, as with timing or other sequential operations. A pulse switch, SPST, provides a single electrical pulse each time the actuator is depressed, but not when released. When operated by a single-lobed cam, the switch gives one pulse per revolution.

Other special designs include a split-contact double-throw switch, which is suitable for controlling two isolated circuits, and a double-break switch, which makes and breaks a circuit at two points, thus enabling it to interrupt greater inductive loads than is possible with single-break switches.

Contact Action: Unless stated otherwise, all switches discussed in this article series are the momentary-contact type (see *Definitions*, Part 1). Maintained-contact or reset switches, which are not as commonly used as momentary-contact switches,

Table 4—Electrical Ratings of Typical Precision Switches

Switch Type*	Rated Current (amp)	Rated Voltage (v)
Basic switch and Enclosed switch	15 ½ ¼	125, 250, 480 ac 125 dc 250 dc
Subminiature switch	5 3 (inductive, sea level) 2.5 (inductive, 50,000 ft) 5 (resistive) 24 (inrush, max)	125, 250 ac 30 dc 30 dc 30 dc 30 dc
Limit switch	10 ½ hp 1 hp 0.8 0.4 0.1 Pilot duty	120, 240, 480 ac 120 ac 240 ac 115 dc 230 dc 550 dc 600 ac max

*See Table 1 in Part 1 for description of switch types.

require two separate operations—one operation of the switch throws the electrical contact in one direction where it remains until a second operation, usually on a separate button, returns the contact to its original position. Such switches are frequently used as safety interlocks to detect unsafe or improper situations and keep the circuit open until the faulty condition is corrected. A rotary-action, double-roller-lever switch with maintained contacts, Fig. 35, is useful in applications where an overriding reciprocating member operates the switch.

Another mechanical action which is electrical in function is obtained with a one or two-way rotary-lever actuator. Electrical operation can be provided when the actuator is moved in either direction or in only one direction, either clockwise or counterclockwise, while still allowing the actuator to move through its entire travel in both directions. This feature is available with such types as shown in Fig. 19 (Part 1), 26a, and 36.

Available as a plug-in device, the switch in Fig. 36 also contains two separate basic switches, each with a two-circuit double-break contact arrangement. Movement of the actuator arm in one direction operates one switch; movement in the opposite direction operates the other. A variation allows both switches to be operated in either direction in an adjustable sequence. Thus, use of one limit switch can reduce chance of failures and save space, wiring, and cost of separate switches and relays.

One other switch design, shown in Fig. 37, provides a momentary contact even though the plunger



Fig. 37—Enclosed type of switch which provides electrical pulse actuation whether plunger is released or not.

actuator is held depressed. When controlling pneumatic valves where permanent-duty solenoids are not used, for example, this switch can prevent electrical component failure resulting from prolonged circuit energization.

Load: Keeping electrical loads on switches within published capabilities is of primary importance. Precision switches are frequently selected on the basis of continuous current rating of motors and solenoids without proper consideration for inrush capacity. The result in such applications is a set of welded contacts the first time the equipment is turned on.

Ratings of typical switches are given in Table 4. Regardless of the type of switch, electrical life varies with load. Many switches which handle only pilot circuits have a long trouble-free life. If heavier currents than normal are applied, electrical failure generally results ahead of mechanical trouble.

Likewise, the higher the electrical load, the greater the effect on repeatability of switch operating characteristics. With some types of precision switches, over 20 million electrical operations can be expected under controlled conditions.

Alternating Current: Electric power which can be reliably controlled at rated life often seems out of proportion to the size of many basic switches—for example, Fig. 10, Part 1 (7 amp, 115/230 v ac, 0.2 by 0.35 by 0.5 in.). Experience has shown, however, that the Underwriters' Laboratories Inc. ratings recommended by most switch manufacturers are conservative. At rated loads difficulty with prompt interruption of 60-cycle ac loads is unknown at sea-level operating conditions because cyclic current reversals prevent continuous build-up of transfer current on the contacts. Such is not the case with dc loads. However, in 400-cycle ac circuits, interrupting problems may approach those of dc loads.

The effect of temperature rise on switch load is seldom important, except when the rise is caused by arcing at maintained high-speed operations under heavy loads.

Rating limits are determined by the ability of a

switch to close a circuit without sticking or welding of the contacts to an extent which prevents reopening, or which prevents the switch from serving its expected or required life. For this reason, only certain types of switches are rated by Underwriters' Laboratories Inc. for control of tungsten lamps. Instantaneous current flow upon closing the circuit on a cold filament may be more than ten times that for a hot filament. Solenoids and motors also have high current inrush on closure of the circuit.

Often, a potentially higher load may be applied to a switch as the result of failure or jamming of another electrical device in the circuit. If this hazard exists, a switch capable of handling the higher currents is required.

Heavy-duty switches listed by Underwriters' Laboratories Inc. are required to close circuits on an inrush of 75 amp, continuously carry 25 amp, and break circuits carrying 20 amp at potentials up to 260 v ac. This capacity enables a switch to start and stop a 240-v, 2-hp motor directly.

Conversely, electronic equipment poses problems of reliable switching of low-energy current in the millivolt, milliampere range. Special types of switches, generally of subminiature size, have been developed specifically for such use. Special contact materials and design are used to minimize and stabilize contact resistance for extended and reliable life.

Also, special electronic circuits, which have been developed and packaged for use with electromechanical switches, can save developmental time as well as space in control consoles. One such package produces a single, shaped wave impulse regardless of switch operating speed. Another type of circuit generates a single pulse in synchronism with an external clock pulse. A third eliminates spurious voltage pulses caused by minute mechanical contact bounce.

Direct Current: Several of the simple mechanical types of precision snap-acting switches serve well on dc loads up to 30 v. However, all switches are limited by Underwriters' Laboratories Inc. ratings for service on 115 v or higher because the small contact separation may fail to interrupt the arc, particularly on inductive loads.

Not only are dc inductive loads difficult to interrupt, but switch performance is often impossible to predict except by tests. In many installations, however, satisfactory performance on substantial loads can be obtained with condenser and resistor combinations. These arrangements reduce the arc and lessen the transfer of contact materials, which tends to close the separation between contacts. Rectifiers are also used to assist in arc interruption.

Control of dc loads up to 10 amp at 115 v without the use of condensers is provided by switches which contain permanent magnets to extinguish the arcs. However, most switches of this type must be polarized—that is, the plus connection made to the indicated terminal—to make the blowout magnet effective.

In general, relatively high running loads of dc motors can be interrupted without the use of arc-controlled networks because of the small potential appearing at the switch.

Accuracy and Life

Reliability of switch operation depends primarily on mechanical factors; yet electrical loads can have a marked effect on contact life. Operating accuracy is one measure of reliability; life expectancy is another. Important phases of both are covered here.

Repeatability: While pertaining to all operating characteristics, repeatability most often means the ability of the actuator to consistently repeat an operation at some precise point in its travel for a large number of operations. This ability is a requisite in such applications as gaging and precise control of machine tools.

Two often misunderstood points regarding repeatability are:

1. Repeatability is independent of small operating and differential energy. For example, a switch which can be snapped from one position to the other by a motion of 0.002 in. may have even superior repeatability to one requiring only 0.0002 in. Frequently, switches are mistakenly specified with unnecessarily close differentials. As a result, electrical capacity is lower or contact life is shorter (because of closer contact spacings) than can be obtained from switches having wider differential characteristics.

2. Maximum repeatability can be secured only on small electrical loads, usually no greater than 0.1 amp.

Mechanically, precise repeatability is accomplished by switch construction, which maintains a fixed point of application of operating motion to the snap-acting spring. Ordinary types of basic switches have repeatability on the order of 0.0005 in. through 100,000 operations under small electrical load. However, under maximum load, the amount of variation may increase to 0.005 in. because increased operating force and motion are required to overcome the small

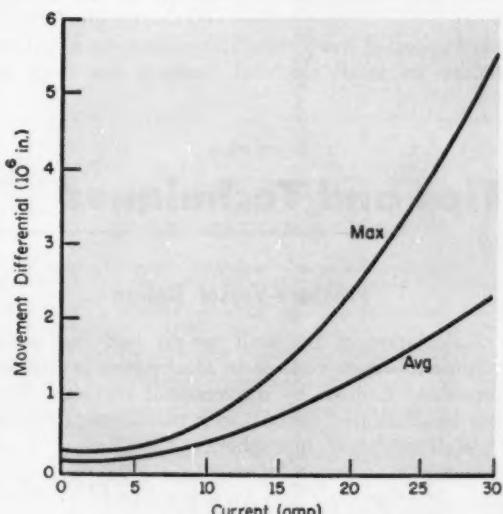


Fig. 38—Relationship of movement differential and load current at 110 v ac.

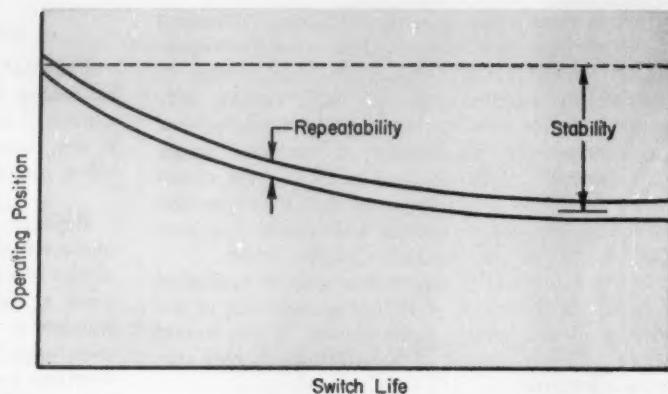


Fig. 39—Relationship of stability of operating position and switch life.

contact weld caused by the higher electrical load, Fig. 38.

Special units repeat operation with a plunger position which varies no more than 0.00015 in. over one million operations. This degree of precision requires controlled ambient temperature, electrical load no greater than 10 w at 120 v ac, and possible use of an interposed relay to prevent contact welding and erosion.

Closely related with repeatability is stability or drift in the original operating position as a result of wear in the switch and parts of the operating device and possible variations in environmental conditions, Fig. 39. The degree of repeatability is inherent in switch design and construction; drift may be compensated for by readjusting the switch location.

Life: Unless a switch is subjected to abrasive dust or other wearing atmospheres or is improperly applied, its mechanical life is usually determined by the flexure life of one of its springs. Wide contact spacing of the snap-action switching spring for heavy loads and wide operating motion of the actuator mean higher fatigue stresses and shorter life. Switches have operated more than 150 million times without failure on small electrical loads at less than full

stroke. Spring materials, however, are not entirely homogeneous, and data on probable switch life are generally based on a full stroke of the switch actuator at each operation. For these reasons, probable life above 20 million operations is not usually predicted.

Minimum required mechanical life must be arbitrarily arrived at after studying the application and deciding upon the number of operations which would be considered adequate before replacing the switch. Where a switch is subjected to many millions of operations over a short period of time, as on high-speed machines, switch selection and provision for easy replacement should be given special consideration. Plug-in types, Fig. 19 in Part 1, are frequently recommended.

Under full rated electrical load, contacts usually reach their full useful life in less than the probable mechanical life of the spring system. In many cases, however, probable contact life up to ten million operations may be expected. As ultimate contact life is approached, intermittent sticking of contacts may occur. On critical applications where no failures can be tolerated, routine switch replacement after suitable service should be practiced. Cost of such replacement is often less than even brief downtime for emergency replacement.

Tips and Techniques

Pressure-Vessel Design

Calculation of the wall weight and the useful-volume to weight ratio of an ideal sphere is a tedious procedure if done by conventional methods. They can be calculated directly with two simple formulas.

Wall weight, W , of a sphere is

$$W = \frac{4\rho\pi}{3} [(a+t)^3 - a^3]$$

where ρ = density of wall material, lb/in.³; a =

inside radius of sphere, in.; and t = wall thickness, in.

Ratio of useful volume to weight, μ , is

$$\mu = \rho \frac{3\phi}{2 - \phi}$$

where $\phi = P/S$; P = internal pressure, psi; and S = maximum tangential stress, psi. Note that μ is independent of the radius of the sphere.—CHARLES E. MATHAY, Development Engineer, Thompson Ramo Wooldridge Inc., Cleveland, Ohio.

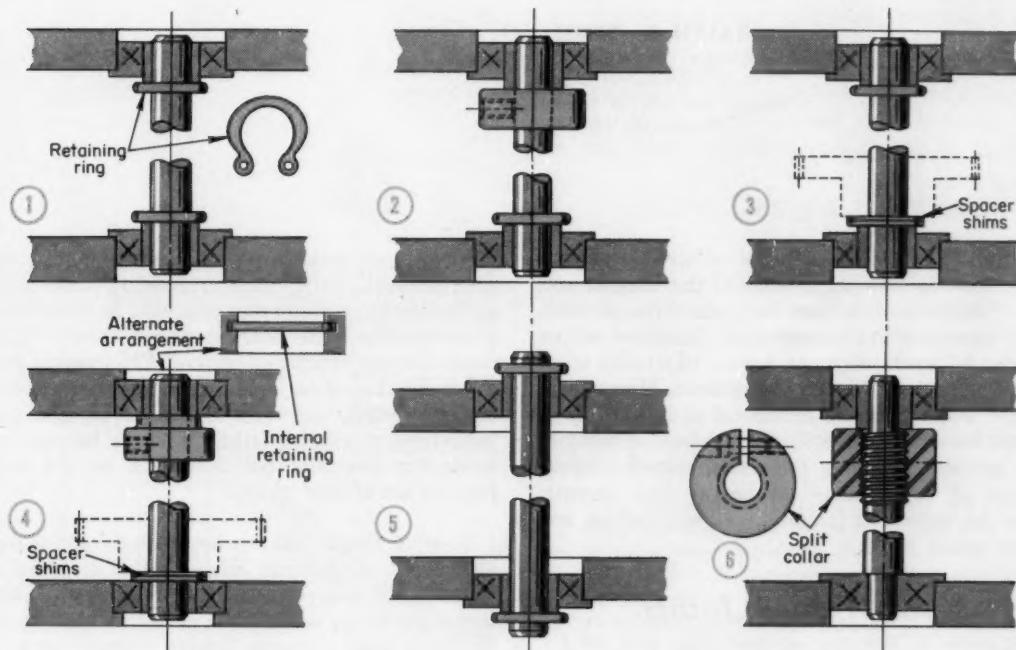
Design guides for

Positioning Gear Shafts

FRANK WILLIAM WOOD JR., Advanced Designs Inc., Vienna, Va.

IN precision gear trains, both backlash of the system and wear of the gear teeth are minimized by accurate positioning of the gear shafts. Radial accuracy depends on the precision of the

bored holes in the housing walls. Precise axial location of shafts between end plates can be provided by any of a number of arrangements. This article presents six.



Design	Features	Requirements
1. Retaining rings at both ends of shaft	Shaft subassemblies usually can be preassembled. No adjustment required at final assembly. End plates can be line-bored.	Uses flange-type bearings with extended inner races (or with adequate radial clearance between races to clear retaining ring). Close tolerance must be held between ring grooves.
2. Retaining ring at one end, collar at other	No close tolerances required on shaft machining. End plates can be line-bored.	Requires flange-type bearings with extended inner races (or, collar can be stepped).
3. Retaining ring at one end, gear hub at other	No close tolerances required on shaft machining. End plates can be line-bored.	Requires flange-type bearings with extended inner races.
4. Collar at one end, spacer shims at other	No shaft machining.	Uses flangeless bearings. End plates require counterboring. (Alternate arrangement requires internal retaining ring.)
5. Exterior retaining rings at both ends of shaft	Retaining rings are easy to remove. End plates can be line-bored.	Requires flange-type bearing with extended inner races. Close tolerance must be held between ring grooves. Exterior clearance needed for shaft and bearing flange.
6. Threaded, split collar at one end, stepped shaft	Threaded adjustment removes axial play at assembly. End plates can be line-bored.	Uses flange-type bearings with extended inner races. Shaft requires more machining than other designs. Plates must be separated for shaft removal.

Fatigue in Metal Joints

How to determine design strengths using simplified data from modified S-N curves

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THE FATIGUE resistance of a welded joint depends more on the skill of the designer and fabricator than does any other type of joint. Stress concentrations unknowingly "designed in" or "welded in" such joints can have a significant effect on the endurance life of a weldment. Hence, production welds must be considered cautiously, even though laboratory welds show good fatigue strength. This article, concluding the series, considers specification of high-quality weldments and presents curves for estimating fatigue life of spot-welded and fusion-welded joints.

Spot-Welded Joints

Differences in properties between the weld nugget and the parent material have an important effect on fatigue strengths of spot-welded joints in various materials. For example, a comparison of spot-welded Cor-Ten and 18-8 stainless steels¹ showed that spot-weld fatigue strength was about the same for both. Yet the Cor-Ten steel had an ultimate static strength of only 63 per cent of that of the 18-8 stainless steel. The two alloys obviously were affected differently by the heat required for spot welding. The weld heat increased the hardness of the Cor-Ten, and fatigue cracks started at the edge of the heat-affected zone. The weld heat softened the stainless steel, however, and fatigue cracks initiated at the junction of the two sheets.

Heat Treatment: For aluminum materials, post-weld heat treatment of spot welds has little effect on fatigue properties. For alloy steels, however, the

possibility of embrittlement of weld nugget and parent metal during heat treatment causes many authorities to conclude that post-weld heat treatment is undesirable. This characteristic is shown by the results of tests conducted on 17-7 PH stainless steel, Table 1.² Lap-shear values are indicative of static design strength, and cross-tension values give good indications of relative fatigue strength because spot weldments generally fail in fatigue by the welds popping out of their sockets.

Strength Ratio: The tension-to-shear ratio is especially useful when stress values on S-N diagrams are given in per cent of ultimate static strength. Other factors remaining equal, when ultimate static strength of a spot weld increases, fatigue strength, as a per cent of ultimate static strength, decreases sharply. Generally, higher static strengths are achieved by using higher temperatures and/or longer weld times. Both of these practices tend to produce cracks which cause failure under cyclic loading.

Test Results: A convenient summary of data from available literature on strength of spot welds is given in Fig. 1. This band of fatigue values for aluminum alloys shows maximum repeated direct load as a per cent of ultimate static direct load on the joint (where stress ratio $r = 0$).

Fusion-Welded Joints

Similar data can be grouped in a design band or design curve for fusion-welded joints. A logical classification of such information would start with high-quality butt welds under direct load (with the

¹References are tabulated at end of article.

2—Welded Joints

weld in tension). High-quality weldments are characterized by these features:

1. Joints are welded from both sides by calibrated automatic equipment.
2. Beads are continuous; no starts and stops should be present.
3. Beads are continued around the ends of joints and ground to smooth transitions.
4. Welds are ground flush.
5. Joints are radiographed periodically.

Design curves for fusion-welded joints in steel and aluminum are shown, Fig. 2, along with curves for spot-welded joints in steel, aluminum, and titanium. All curves are for joints under direct load, from zero to maximum stress only (stress ratio $r = 0$). The values shown include no safety factor on ultimate static strength; a safety factor in fatigue equal to that used in static design should be applied.

S-N Design Curves

When a weld is something less than high quality, or when factors of loading or configuration lessen the joint efficiency, several limitations apply to the curves of Fig. 2 for fatigue-life determination.

Fusion-Welded Joints: Curve A is for fusion-welded joints in steels and aluminums and can also be used to approximate joint strengths in other materials. Design factors to be applied are:

1. For standard-quality butt welds, use 50 per cent of the fatigue life shown. A standard-quality weld must be radiographed periodically to insure quality but is not necessarily flush ground, may contain some starts and stops in a seam, or may otherwise not measure up to highest quality.
2. For butt welds from one side only, or where poor concentration is expected, use 20 per cent of the fatigue life shown.
3. For good-quality fillet welds under direct load (weld is in shear) use 30 per cent of the fatigue life shown. A good-quality fillet weld is one having the "dead-end" plate beveled and welded from both sides.
4. For lap welds under direct load, use 20 per cent of the fatigue life shown.
5. For loads that involve bending or twisting of any of

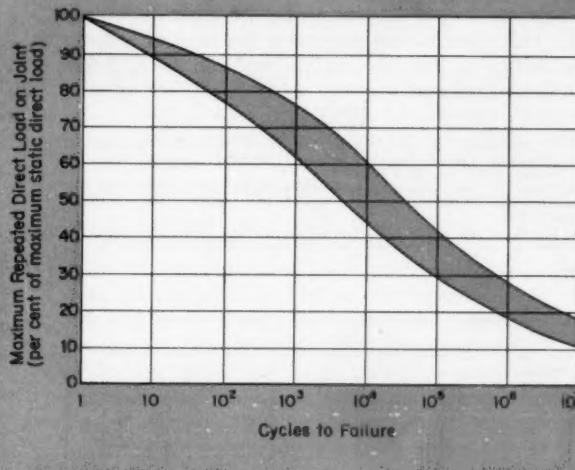


Fig. 1—S-N band for a single spot weld in aluminum alloys 7075, 2024, and 2014 (T-3 or higher). Band represents fatigue values for conditions where stress ratio $r=0$.

Table 1—Effect of Post-Weld Heat Treatment on Spot-Welded 17-7 Steel

Pre-Weld Condition	Post-Weld Treatment	— Post-Weld Hardness (Bhn) —	Cross Tension (lb)	Lap Shear (lb)	Ratio, Tension to Shear
		Parent Metal Nugget Edge Nugget Center			
Annealed	None	175	200-230	200	370
Annealed	1050 F. 1 1/2 hr	375	315-320	350	330
1400 F. 1 1/2 hr	None	375	250	290	540
1050 F. 1 1/2 hr	1050 F. 1 1/2 hr	350	310	330	380
1400 F. 1 1/2 hr	1050 F. 1 1/2 hr				

these weld types, use 50 per cent of the fatigue life already determined.

Spot-Welded Joints: Curve *B*, Fig. 2, is the lower edge of the design band of Fig. 1. This curve ap-

Common Causes of Weldment Failure

- Insufficient edge distance or land width.
- Excessive rigidity and continuity designed into a welded-joint structure. Rigidity brings high loads to the joints which have relatively low ductility and cannot flow plastically under occasional overload. Continuity (not generally present in an equivalent mechanical joint) may help a fatigue crack, once initiated, to continue into an adjacent member.
- Insufficient attention during the design stage to notch effects.
- Changes in metallurgical structure due to heat of welding. Fatigue cracks often initiate in a fillet weld in the transition zone between weld and parent material.
- Nonhomogeneity of material and the "welding-in" of high residual stresses. In welding, where brittle constituents are formed, the plasticity which enables structure to withstand deformation is limited. Thus, cracks may be initiated which often result in fatigue failure. If the residual effect is isolated and it alone measured, relatively consistent effects have been observed. For soft materials, residual stresses have little effect because the first few cycles of repeated load remove them. For hard materials, however, the residual stresses are not removed by the initial fatigue cycles. Generally residual tensile stresses cause reduced fatigue strength and residual compressive stresses cause increased fatigue strength.
- Use of welds in the proximity of high-frequency, low-amplitude vibrations (jet engines, for example) without proper regard to fatigue considerations.

plies to high-quality, medium static strength spot welds in stainless steels, carbon steels, and 2014, 2024, and 7075 bare or clad aluminums (T-3 or higher). Design factors that apply are:

1. Total thickness of metals should be between 0.025 and 0.125 in. (equal or unequal) with lap eccentricity (distance between centers of loading forces) up to $\frac{1}{6}$ in.
2. No post-weld heat treatment should be used.
3. No specific factor can be given for other than high-quality spot welds.
4. Because of space limitations, a design may require spot welds of higher static strength than normal. Fatigue strength of spot welds (as a per cent of static strength) decreases with increased static strength. A weld callout of 10 per cent above normal (medium range) static strength may be made without penalty. However, for each additional 10 per cent static strength increase, decrease fatigue life found from the curve by 20 per cent.
5. Curve *B* is for spot welds in lap shear. Static-design allowances for tensile stresses caused by other forces are usually adequate for fatigue design.

Curve *C*, Fig. 2, is used to estimate endurance life of spot welds in titanium parts. Design factors of Curve *B* apply except that special consideration is necessary for welds under tensile load because of the low tensile-to-shear strength ratio of titanium. Further testing is needed to obtain conclusive data on fatigue life of titanium spot welds.

Multiple Groupings: The S-N curves of Fig. 2 that deal with spot-welded joints are for a single weldment loaded in shear. For multiple groupings the reduction factors given for mechanical-fastener groupings³ should be used in addition to all other factors mentioned.

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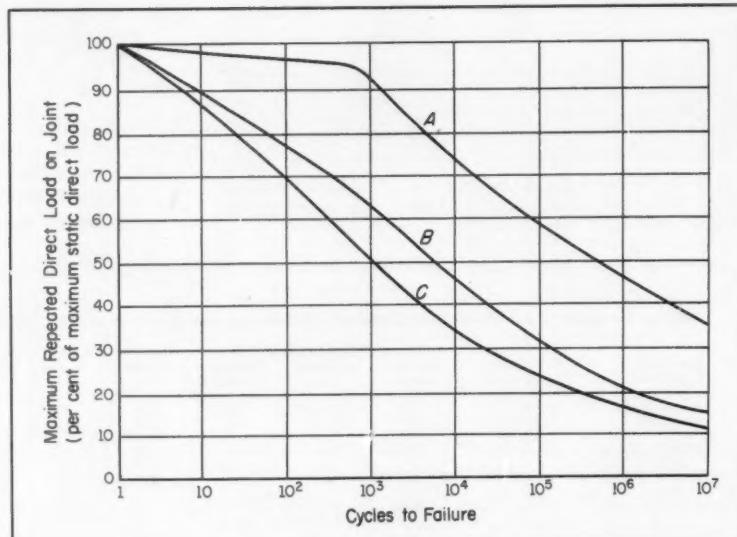


Fig. 2—S-N curves for high-quality welded joints. Curve *A* is for fusion-welded steel and aluminum; curve *B*, spot-welded steel, stainless steel, and aluminum; curve *C*, spot-welded pure and low-alloy titanium.

A simplified, universal procedure for

Designing Cam Profiles

Tables and equations speed development of polynomial cam curves to fit mixed conditions of displacement, velocity, and acceleration

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WHEN the function of a cam is simply to move a follower through a definite displacement in a prescribed time, design requirements usually can be satisfied by one of the basic curve forms: Cycloidal, harmonic, parabolic, etc. Final choice will depend only on the type of motion which is judged to be best for the particular event.

When stringent terminal or intermediate conditions are imposed, the basic curves require considerable manipulation to achieve the required objectives. Usually some compromise must be reached with resultant deterioration of desirable features.

Another possibility is to resort to a polynomial curve, tailored to satisfy the specific problem requirements. However, if more than six conditions are involved, a polynomial of high order will result. Without high-speed computing equipment, the mathematics becomes tedious and time-consuming.

This article presents a method of combining low-power polynomials to meet specified conditions. Mathematical operations are relatively simple, and

can be easily and quickly handled with slide rule and desk calculator. The procedures outlined will produce continuous and finite velocity, acceleration, and pulse (jerk) curves.

Design Equations

Consider any cam-displacement curve where the event takes place in time t . Let original displacement $y_0 = 0$ and final displacement $y_F = h$. Typical displacement diagrams appear in Fig. 1.

The general polynomial¹ to accommodate six conditions is:

$$y = C_0 + C_1x + C_2x^2 + C_3x^3 + C_4x^4 + C_5x^5 \quad (1)$$

Differentiating this equation successively with respect to time, evaluating constants, and collecting terms give the equations for displacement (y), velocity (dy/dt), acceleration (d^2y/dt^2), and pulse

¹References are tabulated at end of article.

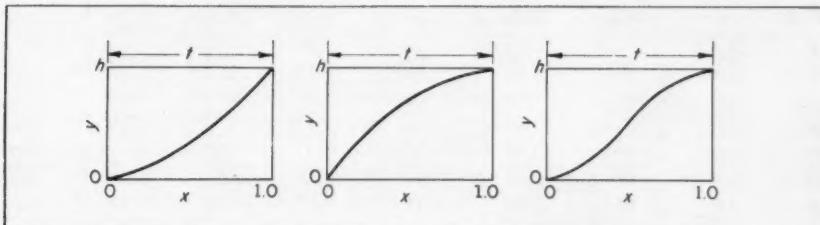


Fig. 1—Typical cam-displacement diagrams where event takes place in time t .

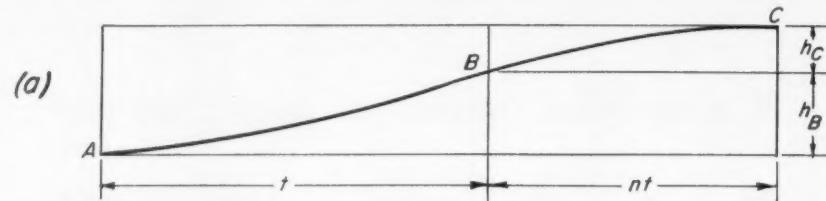
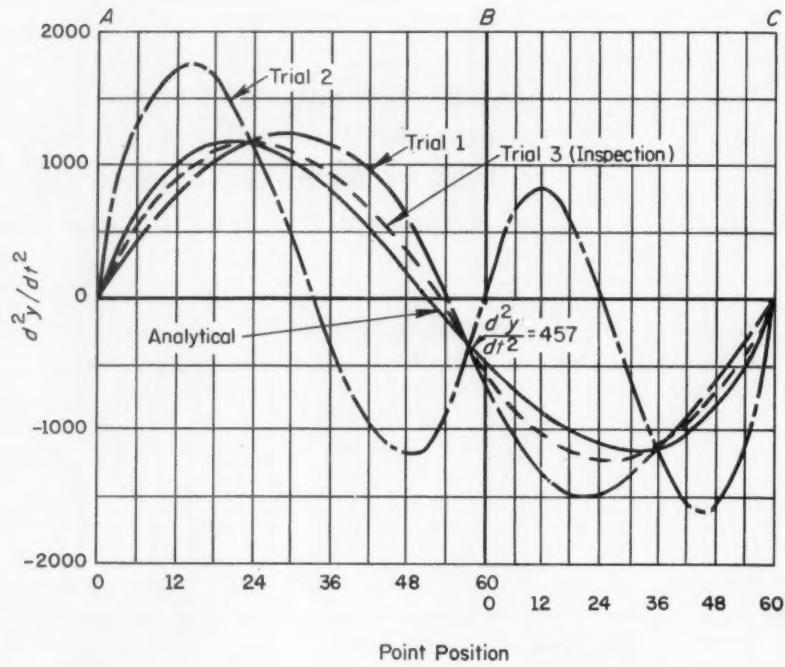


Fig. 2—Dwell-rise-dwell cam with intermediate displacement: *a*, displacement diagram; *b*, acceleration diagram and trial calculations.



(b)

Trial Calculations

Point	x	First Trial				Curve BC			
		400A ₁	736A ₃	-600A ₅	d^2y/dt^2	400A ₁	981A ₂	-600A ₄	d^2y/dt^2
0	0	0	0	0	0	0	0	-600	-600
6	0.10	1728	-1192	-114	422	1728	-2849	-162	-1083
12	0.20	2304	-1413	-120	771	2304	-3767	96	-1367
18	0.30	2016	-927	-54	1035	2016	-3708	210	-1482
24	0.40	1152	0	48	1200	1152	-2825	216	-1457
30	0.50	0	1104	150	1254	0	-1471	150	-1321
36	0.60	-1152	2120	216	1184	-1152	0	48	-1104
42	0.70	-2016	2782	210	976	-2016	1236	-54	-834
48	0.80	-2304	2826	98	618	-2304	1884	-120	-540
54	0.90	-1728	1987	-162	97	-1728	1589	-114	-253
60	1.00	0	0	-600	-600	0	0	0	0

Second Trial

Point	x	Curve AB				Curve BC			
		400A ₁	286A ₃	d^2y/dt^2	400A ₁	381A ₂	d^2y/dt^2		
0	0	0	0	0	0	0	0	0	0
6	0.10	1728	-463	1265	1728	-1029	699		
12	0.20	2304	-549	1755	2304	-1463	841		
18	0.30	2016	-360	1656	2016	-1440	576		
24	0.40	1152	0	1152	1152	-1097	55		
30	0.50	0	429	429	0	-571	-571		
36	0.60	-1152	823	-329	-1152	0	-1152		
42	0.70	-2016	1080	-936	-2016	480	-1536		
48	0.80	-2304	1097	-1207	-2304	732	-1572		
54	0.90	-1728	772	-956	-1728	617	-1111		
60	1.00	0	0	0	0	0	0		

(d^3y/dt^3) . These lengthy equations may be simplified to:

$$y = H_1 h + H_2 v_0 t + H_3 v_F t + H_4 a_0 t^2 + H_5 a_F t^3 \quad (2)$$

$$\frac{dy}{dt} = V_1 \frac{h}{t} + V_2 v_0 + V_3 v_F + V_4 a_0 t + V_5 a_F \quad (3)$$

$$\frac{d^2y}{dt^2} = A_1 \frac{h}{t^2} + A_2 \frac{v_0}{t} + A_3 \frac{v_F}{t} + A_4 a_0 + A_5 a_F \quad (4)$$

$$\frac{d^3y}{dt^3} = P_1 \frac{h}{t^3} + P_2 \frac{v_0}{t^2} + P_3 \frac{v_F}{t^2} + P_4 \frac{a_0}{t} + P_5 \frac{a_F}{t} \quad (5)$$

where v_0 = original velocity, v_F = final velocity,

a_0 = original acceleration, a_F = final acceleration, and

$$H_1 = 10 x^3 - 15 x^4 + 6 x^5$$

$$H_2 = x - 6 x^3 + 8 x^4 - 3 x^5$$

$$H_3 = -4 x^3 + 7 x^4 - 3 x^5$$

$$H_4 = \frac{x^2}{2} - \frac{3x^3}{2} + \frac{3x^4}{2} - \frac{x^5}{2}$$

$$H_5 = \frac{x^3}{2} - x^4 + \frac{x^5}{2}$$

Corresponding expressions for coefficients V , A , and P may be determined directly from these expressions for H by successive differentiation. For example, $V_1 = 30x^2 - 60x^3 + 30x^4$, $A_1 = 60x - 180x^2 + 120x^3$, and $P_1 = 60 - 360x + 360x^2$.

Values of coefficients H , V , A , and P are tabulated in Tables 1 through 4 for the range from $x = 0$ to $x = 1$. Table 1 (displacement) provides for 60

Table 1—Displacement Factors

Pt.	x	H_1	H_2	H_3	H_4	H_5
0	0	0	0	0	0	0
1	0.000045	0.016639	-0.000018	0.000132	0.000002	
2	0.000352	0.03121	-0.000140	0.000502	0.000017	
3	0.05	0.001158	0.049299	-0.000457	0.001072	0.000056
4	0.02675	0.065043	-0.001051	0.001807	0.000129	
5	0.005088	0.080235	-0.001989	0.002674	0.000243	
6	0.10	0.008560	0.094770	-0.003330	0.003645	0.000405
7	0.013230	0.108556	-0.005120	0.004691	0.000620	
8	0.019216	0.121513	-0.007396	0.005786	0.000890	
9	0.15	0.026612	0.133572	-0.010184	0.006909	0.001219
10	0.035494	0.144676	-0.013503	0.008038	0.001607	
11	0.045917	0.154777	-0.017362	0.009153	0.002055	
12	0.20	0.057920	0.163940	-0.021760	0.010240	0.002560
13	0.071521	0.171837	-0.026691	0.011282	0.003121	
14	0.086724	0.178750	-0.032140	0.012267	0.003733	
15	0.25	0.103516	0.184570	-0.038086	0.013184	0.004395
16	0.121869	0.189298	-0.044500	0.014022	0.005099	
17	0.141742	0.192939	-0.051348	0.014775	0.005841	
18	0.30	0.163080	0.195510	-0.058590	0.015435	0.006615
19	0.185817	0.197031	-0.061182	0.015988	0.007414	
20	0.209874	0.197531	-0.074074	0.016461	0.008230	
21	0.35	0.235169	0.197043	-0.082213	0.016821	0.009057
22	0.261599	0.195809	-0.080541	0.017077	0.009887	
23	0.289060	0.193271	-0.098997	0.017230	0.010710	
24	0.40	0.317440	0.190080	-0.107520	0.017280	0.011520
25	0.346619	0.186089	-0.116042	0.017230	0.012307	
26	0.376474	0.181356	-0.124407	0.017084	0.013084	
27	0.45	0.406873	0.175942	-0.123215	0.016845	0.013783
28	0.437685	0.169908	-0.140926	0.016519	0.014454	
29	0.468773	0.163322	-0.148762	0.016110	0.015071	
30	0.50	0.500000	0.156250	-0.156250	0.015625	0.015625
31	0.531227	0.148762	-0.163322	0.015071	0.016110	
32	0.562315	0.140926	-0.169908	0.014454	0.016519	
33	0.55	0.593127	0.132815	-0.175942	0.013783	0.016845
34	0.623526	0.124497	-0.181356	0.013064	0.017084	
35	0.653381	0.116042	-0.186089	0.012307	0.017230	
36	0.60	0.682500	0.107520	-0.190008	0.011520	0.017280
37	0.710940	0.098997	-0.193271	0.010710	0.017230	
38	0.738401	0.090541	-0.195609	0.009887	0.017077	
39	0.65	0.764811	0.082213	-0.197043	0.009057	0.016821
40	0.790124	0.074014	-0.197531	0.008230	0.016461	
41	0.814184	0.066182	-0.197031	0.007414	0.015998	
42	0.70	0.836920	0.058590	-0.195510	0.006615	0.015435
43	0.858258	0.051348	-0.192939	0.005841	0.014775	
44	0.878131	0.044500	-0.189298	0.005099	0.014022	
45	0.75	0.896484	0.038086	-0.184570	0.004395	0.013184
46	0.913276	0.032140	-0.178750	0.003733	0.012267	
47	0.928479	0.026891	-0.171837	0.003121	0.011282	
48	0.80	0.942080	0.021760	-0.163840	0.002560	0.010240
49	0.954083	0.017362	-0.154777	0.002055	0.009153	
50	0.964505	0.013503	-0.144672	0.001607	0.008038	
51	0.85	0.973388	0.010184	-0.133572	0.001219	0.006909
52	0.980784	0.007396	-0.121513	0.000890	0.005786	
53	0.986770	0.005120	-0.108556	0.000620	0.004691	
54	0.90	0.991440	0.003230	-0.094770	0.000405	0.003645
55	0.994912	0.001989	-0.080235	0.000243	0.002674	
56	0.997325	0.001051	-0.065043	0.000129	0.001807	
57	0.95	0.998842	0.000457	-0.049299	0.000056	0.001072
58	0.999648	0.000140	-0.033121	0.000017	0.000502	
59	0.999955	0.000018	-0.016639	0.000002	0.000132	
60	1.00	1.000000	0	0	0	0

Table 2—Velocity Factors

Pt.	x	V_1	V_2	V_3	V_4	V_5
0	0	0	1.00000	0	0	0
3	0.05	0.08769	0.95891	-0.02659	0.03948	0.00327
6	0.10	0.24300	0.85050	-0.09350	0.06075	0.01125
9	0.15	0.48769	0.69541	-0.18309	0.06773	0.02152
12	0.20	0.76800	0.51200	-0.28000	0.06400	0.03200
15	0.25	1.05469	0.31641	-0.37109	0.05273	0.04102
18	0.30	1.32300	0.12250	-0.44550	0.03675	0.04725
21	0.35	1.55269	0.05809	-0.49459	0.01848	0.04977
24	0.40	1.72800	-0.21600	-0.48500	0.00000	0.04800
27	0.45	1.83769	-0.34409	-0.49359	-0.01702	0.04177
30	0.50	1.87500	-0.43750	-0.43750	-0.03125	0.03125
33	0.55	1.83769	-0.49359	-0.34409	-0.04177	0.01702
36	0.60	1.72800	-0.51200	-0.21600	-0.04500	0.00000
39	0.65	1.55269	-0.49459	-0.05809	-0.04977	-0.01848
42	0.70	1.32300	-0.44550	0.12250	-0.04725	-0.03675
45	0.75	1.05469	-0.37109	0.31641	-0.04102	-0.05273
48	0.80	0.76800	-0.28000	0.51200	-0.03200	-0.06400
51	0.85	0.48769	-0.18309	0.69541	-0.02153	-0.06773
54	0.90	0.24300	-0.09350	0.85050	-0.01125	-0.06075
57	0.95	0.06769	-0.02659	0.95891	-0.00321	-0.03948
60	1.00	0	0	1.00000	0	0

Table 3—Acceleration Factors

Point	x	A_1	A_2	A_3	A_4	A_5
0	0	0	0	0	1.00	0.00
6	0.10	4.32	-2.70	-1.62	0.27	0.19
12	0.20	2.76	-3.84	-1.92	-0.16	0.20
18	0.30	5.04	-3.78	-1.26	-0.35	0.09
24	0.40	2.88	-2.88	0	-0.36	-0.08
30	0.50	0	-1.50	1.50	-0.25	-0.25
36	0.60	-2.88	0	2.88	-0.08	-0.36
42	0.70	-5.04	1.26	3.78	0.09	-0.35
48	0.80	-5.76	1.92	3.84	0.20	-0.16
54	0.90	-4.32	1.62	2.70	0.19	0.27
60	1.00	0	0	0	0	1.00

Table 4—Pulse Factors

Point	x	P_1	P_2	P_3	P_4	P_5
0	0	60.00	-36.00	-24.00	-9.00	3.00
6	0.10	27.60	-18.60	-9.00	-5.70	0.90
12	0.20	2.40	-4.80	2.40	-3.00	-0.60
18	0.30	-15.60	5.40	10.20	-0.90	-1.50
24	0.40	-28.40	12.00	14.40	0.60	-1.80
30	0.50	-30.00	15.00	15.00	1.50	-1.50
36	0.60	-26.40	14.40	12.00	1.80	-0.60
42	0.70	-15.60	10.20	5.40	1.50	0.90
48	0.80	2.40	-4.80	-4.80	0.60	3.00
54	0.90	27.60	-9.00	-18.60	-9.00	5.70
60	1.00	60.00	-24.00	-36.00	-3.00	9.00

divisions, which will be the basis of reference for all intermediate points. For example, in a curve between terminal points *A* and *B*, the 24th point ($x = 0.4$) will be identified as point *AB-24*.

Equations 2 through 5 display some interesting characteristics:

1. If v_0 , v_F , a_0 and a_F are zero, the acceleration is a sine curve, similar to the cycloidal.
2. If $v_0 = 0$, $v_F = 0$, $a_0 = \pi^2 h/2t^2$, and $a_F = -\pi^2 h/2t^2$, the acceleration is a cosine curve, similar to the harmonic.
3. If $v_0 = v_F = Ch/t$, and a_0 and a_F are zero, the motion is constant velocity with a velocity factor of *C*.
4. If $v_0 = 0$, $v_F = 2h/t$, and $a_0 = a_F = 2h/t^2$, result is a positive constant-acceleration curve.
5. If $v_0 = 0$, $v_F = 2h/t$, and $a_0 = a_F = -2h/t^2$, result is a negative constant-acceleration curve.

Thus, the characteristics of all of the common basic curves are embodied within one set of equations. Application of the tables and equations to the development of suitable cam curves for certain fixed conditions will be shown by specific examples.

Design Examples

Dwell-Rise-Dwell Cam—Fixed Intermediate Displacement: Cam action is shown schematically by the displacement diagram in Fig. 2a. Find the optimum displacement equations when $h_B = 0.64$ in.; $h_0 = 0.36$ in.; $t = 0.04$ sec; $nt = 0.03$ sec; velocity at point *A*, $v_A = 0$; velocity at point *C*, $v_G = 0$; acceleration at point *A*, $a_A = 0$; and acceleration at point *C*, $a_G = 0$.

To assure smoothness and continuity of the derivative curves, final velocity v_B , acceleration a_B , and pulse p_B of curve *AB* should equal the initial velocity, acceleration, and pulse of curve *BC*.

The first step is to equalize the pulse. From Table 4 and Equation 5, the pulse at *B* for curve *AB* is:

$$p_B = 60 \frac{h_B}{t^3} - 36 \frac{v_B}{t^2} + 9 \frac{a_B}{t} \\ = 60(10)^4 - 2.25(10)^4 v_B + 2.25(10)^2 a_B \quad (6)$$

Similarly, for curve *BC*,

$$p_B = 60 \frac{h_0}{(nt)^3} - 36 \frac{v_B}{(nt)^2} - 9 \frac{a_B}{nt} \\ = 80(10)^4 - 4(10)^4 v_B - 3(10)^2 a_B \quad (7)$$

Subtracting Equation 6 from Equation 7,

$$0 = 20(10)^4 - 1.75(10)^4 v_B - 5.25(10)^2 a_B$$

Solving for each variable,

$$a_B = 381 - 33.3 v_B \quad (8)$$

$$v_B = 11.43 - 0.03 a_B \quad (9)$$

If any value is assumed for a_B and the corresponding value of v_B is determined from Equation 9 and substituted into Equation 4, point by point accelerations can be calculated and plotted. Successive point

plots for various values of a_B will eventually produce an optimum curve. However, after two trials a suitable curve can be obtained by inspection.

INSPECTION METHOD: For the first trial, let $a_B = -600$. From Equation 9, $v_B = 11.43 - 0.03(-600) = 29.43$.

From Equation 4 for curve *AB*,

$$\frac{d^2y}{dt^2} = A_1 \frac{h_B}{t^2} + A_3 \frac{v_B}{t} + A_5 a_B \\ = 400 A_1 + 736 A_3 - 600 A_5 \quad (10)$$

Similarly, for curve *BC*,

$$\frac{d^2y}{dt^2} = A_1 \frac{h_0}{(nt)^2} + A_2 \frac{v_B}{nt} + A_4 a_B \\ = 400 A_1 + 981 A_2 - 600 A_4 \quad (11)$$

For the second trial, let $a_B = 0$. From Equation 9, $v_B = 11.43$. Then, from Equation 4 for curve *AB*,

$$\frac{d^2y}{dt^2} = 400 A_1 + 286 A_3 \quad (12)$$

and for curve *BC*,

$$\frac{d^2y}{dt^2} = 400 A_1 + 381 A_2 \quad (13)$$

Discrete values of d^2y/dt^2 as calculated from Equations 10 through 13, using Table 3 to evaluate the *A* coefficients, are given and plotted in Fig. 2. Slide rule calculations are usually of sufficient accuracy at this stage.

Inspection of the trial curves, Fig. 2b, reveals certain characteristics. It can be proved that the three intersections are common to all curves with the specified parameters. Therefore, these intersections establish the minimum peak values of positive and negative accelerations. By visual interpolation, a curve which will approach these minimum accelerations can be sketched. Trial curve 3 (dotted line) closely meets the requirements. In this curve $a_B = -500$, which would become the basis for the final curve. From Equation 9, when $a_B = -500$, $v_B = 26.43$.

From Equation 4, the acceleration equations are:

1. Curve *AB*,

$$\frac{d^2y}{dt^2} = 400 A_1 + 661 A_3 - 500 A_5 \quad (14)$$

2. Curve *BC*,

$$\frac{d^2y}{dt^2} = 400 A_1 + 881 A_2 - 500 A_4 \quad (15)$$

From Equation 2, the displacement equations are:

1. Curve *AB*,

$$y = 0.64 H_1 + 1.06 H_3 - 0.80 H_5 \quad (16)$$

2. Curve *BC*,

$$y = h_B + 0.36 H_1 + 0.79 H_2 - 0.45 H_4 \\ = 0.64 + 0.36 H_1 + 0.79 H_2 - 0.45 H_4 \quad (17)$$

ANALYTICAL METHOD: In addition to the trial method, which is quick and efficient, a purely

analytical procedure can be used to give a direct solution.

In Fig. 2b, trial curve 3 slopes upward to the right at terminals A and C, signifying that the pulse at these points is positive. The minimum accelerations possible are at or near points AB-24 and BC-36. This condition is not only true for this curve, but for any curve with fixed terminal conditions where the intermediate displacements and the times of the events are roughly proportional; that is, the larger displacement occurs in the greater time.

If minimum accelerations are to occur at these points, the slope of the acceleration curve (pulse) must be zero. Also, velocity must be positive at all points. From Equation 5 and Table 4 the pulse at terminal A is:

$$p_A = 60 \frac{h_B}{t^3} - 24 \frac{v_B}{t^2} + 3 \frac{a_B}{t}$$

Substituting the known values, eliminating a_B (Equation 8), and simplifying,

$$p_A = 175(10)^2(35.9 - v_B) \quad (18)$$

Thus, p_A will not be negative if $v_B \leq 35.9$.

Similarly, the pulse at terminal C is:

$$\begin{aligned} p_C &= 60 \frac{h_C}{(nt)^3} - 24 \frac{v_B}{(nt)^2} - 3 \frac{a_B}{(nt)} \\ &= 233(10)^2(32.7 - v_B) \end{aligned} \quad (19)$$

Thus, p_C will not be negative when $v_B \leq 32.7$.

Based on Equations 18 and 19, v_B cannot be greater than 32.7.

Let the pulse at point AB-24 equal zero. From Equation 5,

$$0 = -26.4 \frac{h_B}{t^3} + 14.4 \frac{v_B}{t^2} - 1.8 \frac{a_B}{t}$$

Substituting as before and solving give $v_B = 26.8$, which is compatible with the limit condition. Let the pulse at point BC-36 equal zero. Then,

$$0 = -26.4 \frac{h_C}{(nt)^3} + 14.4 \frac{v_B}{(nt)^2} + 1.8 \frac{a_B}{nt}$$

and $v_B = 23.5$, which is also compatible with the limit condition. The logical move now appears to be to take the average of the two computed v_B values. Thus,

$$v_B = \frac{26.8 + 23.5}{2} = 25.15$$

and, from Equation 8,

$$a_B = 381 - 33.3(25.15) = -457$$

This result compares favorably with the value of -500 obtained by inspection.

The acceleration equations are:

1. Curve AB,

$$\frac{d^2y}{dt^2} = 400 A_1 + 629 A_3 - 457 A_5 \quad (20)$$

2. Curve BC,

$$\frac{d^2y}{dt^2} = 400 A_1 + 838 A_2 - 457 A_4 \quad (21)$$

The displacement equations are:

1. Curve AB,

$$y = 0.64 H_1 + 1.006 H_3 - 0.73 H_5 \quad (22)$$

2. Curve BC,

$$y = 0.64 + 0.36 H_1 + 0.755 H_2 - 0.41 H_4 \quad (23)$$

The acceleration curve (analytical) is shown in Fig. 2b.

Dwell-Rise Cam—Fixed Intermediate Displacement and Fixed Terminal Velocity: Displacement diagram is shown in Fig. 3a. Design conditions are: $h_B = 0.250$ in., $h_C = 0.630$ in., $t = 0.02$ sec; $nt = 0.03$ sec, $v_A = 0$, $v_C = 6.0$, $a_A = 0$, and $a_C = 0$. As in the previous example, first equalize the pulse at B. From Table 4 and Equation 5, for curve AB,

$$p_B = 187.5(10)^4 - 9(10)^4 v_B + 4.5(10)^2 a_B \quad (24)$$

and for curve BC

$$p_B = 124(10)^4 - 4(10)^4 v_B - 3(10)^2 a_B \quad (25)$$

Subtracting Equation 24 from Equation 25, and solving for each unknown,

$$a_B = -847 + 66.7 v_B \quad (26)$$

$$v_B = 12.7 + 0.015 a_B \quad (27)$$

From Table 4 and Equations 5 and 26, the pulse at A is:

$$p_A = 5(10)^4(35 - v_B) \quad (28)$$

Thus, p_A will not be negative when $v_B \leq 35$.

Similarly, the pulse at C is:

$$p_C = 3.33(10)^4(37.3 - v_B) \quad (29)$$

Limiting condition is $v_B \leq 35$. Therefore v_B cannot exceed 35.

Let the pulse at point AB-24 equal zero. From Table 4 and Equations 5 and 26, $v_B = 25$, which is compatible with the limit condition.

Let the pulse at point BC-36 equal zero. Solving as before gives $v_B = 29.3$, which is also compatible with the limit condition. Therefore, let $v_B = (25 + 29.3)/2 = 27.15$. From Equation 26, $a_B = 964$.

The acceleration equations are:

1. Curve AB,

$$\frac{d^2y}{dt^2} = 625 A_1 + 1357.5 A_3 + 964 A_5 \quad (30)$$

2. Curve BC,

$$\frac{d^2y}{dt^2} = 700 A_1 + 905 A_2 + 200 A_3 + 964 A_4 \quad (31)$$

The displacement equations are

1. Curve AB,

$$y = 0.25 H_1 + 0.543 H_3 + 0.386 H_5 \quad (32)$$

2. Curve BC,

$$\begin{aligned} y &= 0.25 + 0.63 H_1 + 0.815 H_2 + \\ &0.18 H_3 + 0.868 H_4 \end{aligned} \quad (33)$$

The acceleration curve is shown in Fig. 3b.

Dwell-Rise-Dwell Cam—Fixed Intermediate Displacement with Inverse Time Relationships: In the previous examples, displacements h_B and h_C have occurred in relatively proportional times. When the smaller displacement takes place in the greater time, the procedure becomes slightly more complex. The optimum acceleration curve may not be immediately apparent by the trial and inspection method and, even with the analytical method, some judgment is required to determine the best solution.

The difficulty arises because the minimum peak negative acceleration may not be near point BC-36, as in the previous examples. It may occur between points AB-54 and BC-6 and, for practical purposes, may be assumed to be at point B.

A procedure for checking this cam action is demonstrated here. Consider the displacement diagram shown in Fig. 4a. Design conditions are: $h_B = 0.64$ in., $h_C = 0.36$ in., $t = 0.03$ sec, $nt = 0.04$ sec, $v_A = 0$, $v_B = 0$, $a_A = 0$, and $a_C = 0$. Using the same procedure as in the previous examples,

$$a_B = -2066 + 33.3 v_B \quad (34)$$

$$v_B = 62 + 0.030 a_B \quad (35)$$

Pulse p_A will not be negative when $v_B \leq 52$, and p_C will not be negative, when $v_B \leq 28.1$. Therefore, v_B must be between zero and 28.1.

The position of the minimum possible peak negative acceleration can be determined by the following procedure. From Equation 4 and Table 3, the acceleration at point BC-36 is:

$$\frac{d^2y}{dt^2} = -648 - 0.08 a_B \quad (36)$$

Let $v_B = 0$. Then, from Equation 34, $a_B =$

-2066, and from Equation 36, $a_{BC-36} = -483$. Similarly, when $v_B = 28.1$, $a_B = -1130$ and $a_{BC-36} = -558$.

Thus, for all possible values of v_B , the acceleration at BC-36 is less numerically than the acceleration at B. Therefore, the minimum peak negative acceleration will occur near B.

Let the pulse at point B equal zero. Solving as before, $v_B = 26.8$.

Let the pulse at point AB-24 equal zero. Then $v_B = 35.8$.

The average of these two values, $v_B = 31.3$, is not compatible with the limit condition $v_B \leq 28.1$. The value which is the nearest to 31.3, but does not violate the condition of non-negative pulse at the terminals is $v_B = 28.1$. From Equation 34, this value gives $a_B = -1130$.

The acceleration equations are:

1. Curve AB,

$$\frac{d^2y}{dt^2} = 711 A_1 + 937 A_3 - 1130 A_5 \quad (37)$$

2. Curve BC,

$$\frac{d^2y}{dt^2} = 225 A_1 + 703 A_2 - 1130 A_4 \quad (38)$$

The displacement equations are:

1. Curve AB,

$$y = 0.64 H_1 + 0.843 H_3 - 1.017 H_5 \quad (39)$$

2. Curve BC,

$$y = 0.64 + 0.36 H_1 + 1.124 H_2 - 1.808 H_4 \quad (40)$$

The acceleration curve is shown in Fig. 4b.

Dwell-Rise-Return-Cams — Basic Considerations: None of the basic curves satisfactorily fulfill the

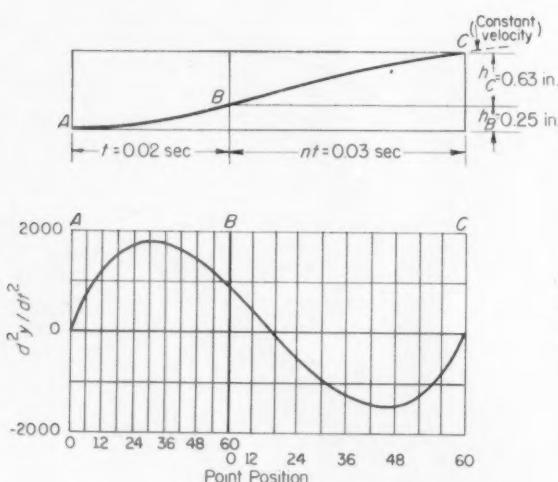


Fig. 3—Dwell-rise cam with intermediate displacement and fixed terminal velocity: a, displacement diagram; b, acceleration diagram.

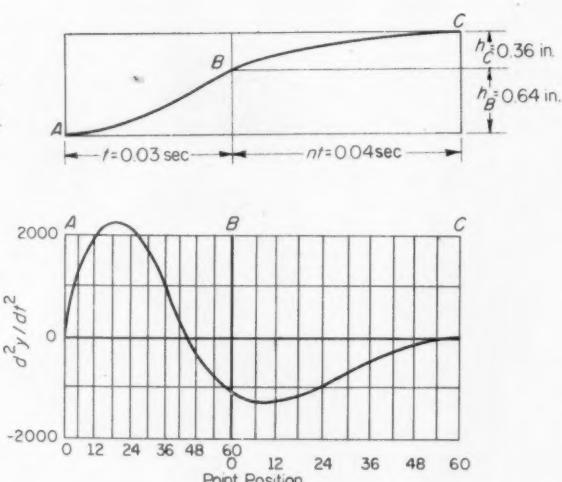


Fig. 4—Dwell-rise-dwell cam with intermediate displacement and inverse time relationships: a, displacement diagram; b, acceleration diagram.

requirements of dwell-rise-return cam action. The cycloidal curve has an unnecessary return to zero acceleration at the maximum rise point. The harmonic curve has infinite pulse at the start of the rise. Combinations of the basic curves, the double-harmonic curve, and certain polynomials have been developed to eliminate these objectionable characteristics. However, when stringent intermediate conditions are introduced, the same difficulties arise as in the D-R-D curve. Basically, the same procedure as described before can be used.

Dwell-Rise-Return Cam—Fixed Intermediate Displacement with Symmetrical Rise and Return: Displacement diagram is shown in Fig. 5a. Design conditions are: $h_B = 0.40$ in., $h_C = 0.60$ in., $t = 0.02$ sec, $nt = 0.02$ sec, $v_A = 0$, $a_A = 0$, $v_B = 0$, $p_B = 0$. Acceleration a_C must be determined. Note that the pulse at point C is zero to insure tangency of the rise and return acceleration curves at this point.

For curve AB, from Equation 5 and Table 4,

$$p_B = 300(10)^4 - 9(10)^4 v_B + 4.5(10)^2 a_B \quad (41)$$

Also, for curve BC,

$$p_B = 450(10)^4 - 9(10)^4 v_B - 4.5(10)^2 a_B + 1.5(10)^2 a_C \quad (42)$$

and

$$p_C = 450(10)^4 - 6(10)^4 v_B - 1.5(10)^2 a_B + 4.5(10)^2 a_C = 0 \quad (43)$$

If Equation 41 is subtracted from Equation 42, simultaneous solution of result and Equation 43 gives

$$a_B = 23.5 v_B \quad (44)$$

$$a_C = 141.2(-70.8 + v_B) \quad (45)$$

Since a_C must be negative and v_B positive, $v_B < 70.8$. From Table 4 and Equations 5 and 44,

$$p_A = 565(10)^2(53.1 - v_B) \quad (46)$$

Thus, p_A will not be negative if $v_B \leq 53.1$. Let the pulse at point AB-24 equal zero. From Equation 5 then, $v_B = 39$. Similarly, if the pulse at point BC-36 equals zero, $v_B = 49.6$. Let $v_B = (39 + 49.6)/2 = 44.3$, which is compatible with Equation 46. Then from Equations 44 and 45, $a_B = 1041$ and $a_C = -3742$.

The acceleration equations are:

1. Curve AB,

$$\frac{d^2y}{dt^2} = 1000 A_1 + 2215 A_3 + 1041 A_5 \quad (47)$$

2. Curve BC,

$$\frac{d^2y}{dt^2} = 1500 A_1 + 2215 A_3 + 1041 A_4 - 3742 A_5 \quad (48)$$

The displacement equations are:

1. Curve AB,

$$y = 0.40 H_1 + 0.886 H_3 + 0.416 H_5 \quad (49)$$

2. Curve BC,

$$y = 0.40 + 0.60 H_1 + 0.886 H_2 + 0.416 H_4 + 1.497 H_5 \quad (50)$$

The acceleration curve is shown in Fig. 5b.

The return is, of course, a mirror image of the rise. Note that if the average of the velocities at points AB-24 and BC-36 had exceeded the velocity limit established by Equations 45 and 46, the choice would be the lower value from these equations.

Dwell-Rise-Return-Cam—Unsymmetrical Periods of Rise and Return: When the function of a cam

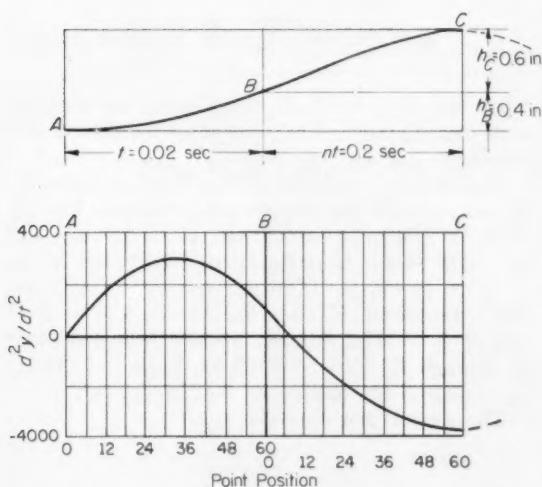


Fig. 5—Dwell-rise-return cam with intermediate displacement and symmetrical rise and return: *a*, displacement diagram; *b*, acceleration diagram.

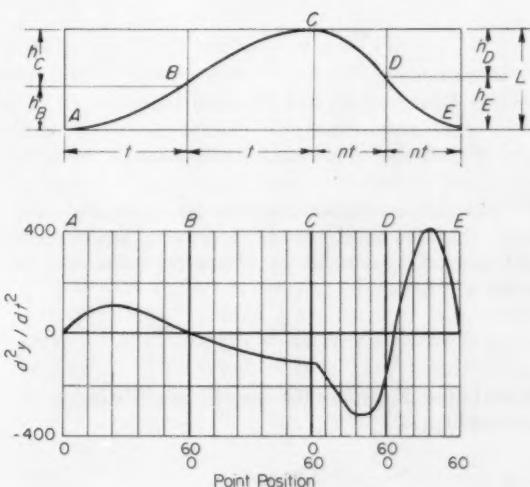


Fig. 6—Dwell-rise-return cam with unsymmetrical periods of rise and return: *a*, displacement diagram; *b*, acceleration diagram.

requires that the rise and return occur in unequal periods of time, the designer is faced with the problems of matching accelerations at the maximum rise point to prevent discontinuity of the acceleration curve. As a solution, Neklutan^{2,3} has developed systems of modified trapezoids and modified sine curves, Schmidt⁴ has proposed combinations of cycloidal and harmonic curves, and Rothbart⁵ has recommended, but not enlarged on, the use of polynomial curves. With the methods demonstrated here, a set of general equations which will meet the requirements of this type of curve can be developed.

A typical displacement diagram is shown in Fig. 6a where L = total displacement, $2t$ = longer time period, and $2nt$ = shorter time period. Intermediate displacements, h_B , h_C , h_D , and h_E are to be determined, as well as the matching acceleration, a_C , at point C. Also, $v_A = 0$, $v_B = 0$, $a_A = 0$, $a_B = 0$, and $p_B = 0$.

For curve AB, solving as before,

$$p_B = 60 \frac{h_B}{t^3} - 36 \frac{v_B}{t^2} + 9 \frac{a_B}{t} \quad (51)$$

and for curve BC,

$$p_B = 60 \frac{(L - h_B)}{t^3} - 36 \frac{v_B}{t^2} - 9 \frac{a_B}{t} + 3 \frac{a_C}{t} \quad (52)$$

Subtracting Equation 51 from Equation 52,

$$0 = 60 \frac{L}{t^3} - 120 \frac{h_B}{t^2} - 18 \frac{a_B}{t} + 3 \frac{a_C}{t} \quad (53)$$

from which,

$$h_B = 0.500 L - 0.150 a_B t^2 + 0.025 a_C t^2 \quad (54)$$

and

$$h_C = 0.500 L + 0.150 a_B t^2 - 0.025 a_C t^2 \quad (55)$$

From Equation 5,

$$p_C = 60 \frac{L - h_B}{t^3} - 24 \frac{v_B}{t^2} - 3 \frac{a_B}{t} + 9 \frac{a_C}{t} = 0 \quad (56)$$

Solving Equations 53 and 56 simultaneously,

$$v_B = 1.250 \frac{L}{t} + 0.250 a_B t + 0.3125 a_C t \quad (57)$$

To establish a relationship between a_B and a_C , assume that the maximum peak positive acceleration will occur at point AB-24. Thus the pulse at this point will be zero:

$$0 = -26.4 \frac{h_B}{t^3} + 14.4 \frac{v_B}{t^2} - 1.50 \frac{a_B}{t} \quad (58)$$

Substituting Equations 54 and 57 into Equation 58 and solving,

$$a_C = -1.250 \frac{L}{t^2} - 1.50 a_B \quad (59)$$

Advantage can be taken of the desirability of having the maximum positive and negative accelerations

the same numerical value. Therefore, let the negative value of the acceleration at point AB-24 equal the acceleration at point C. From Table 3 and Equation 4 then,

$$a_C = - \left(2.88 \frac{h_B}{t^2} - 0.08 a_B \right) \quad (60)$$

Substituting Equation 54 into Equation 60 and solving,

$$a_B = -1.343 \frac{L}{t^2} + 0.478 a_B \quad (61)$$

Combining Equations 59 and 61,

$$a_B = 0.047 \frac{L}{t^2} \quad (62)$$

and from Equation 59 or 61,

$$a_C = -1.321 \frac{L}{t^2} \quad (63)$$

From Equations 54, 55, and 57,

$$h_B = 0.460 L \quad (64)$$

$$h_C = 0.540 L \quad (65)$$

$$v_B = 0.849 \frac{L}{t} \quad (66)$$

By similar methods, assuming that the pulse at point DE-36 is zero and recognizing that displacements and velocities are negative for the return, and the value of a_D is fixed, these equations can be derived for the return curve, CDE:

$$h_D = -L(0.375 + 0.165 n^2) \quad (67)$$

$$h_E = -L(0.625 - 0.165 n^2) \quad (68)$$

$$v_D = -L \frac{\frac{1.042}{n} - 0.193 n}{t} \quad (69)$$

$$a_D = -L \frac{\frac{0.833}{n^2} - 0.880}{t^2} \quad (70)$$

Note that if $n = 1$, these equations are identical with those for curve ABC, except for the signs of displacement and velocity.

Use of these equations is best demonstrated with an example. In the displacement diagram, Fig. 6a, let $L = 2.00$ in., $t = 0.15$ sec, $nt = 0.09$ sec, and $n = 0.60$. Then, from Equations 64, 65, and 66, $h_B = 0.920$ in., $h_C = 1.080$ in., and $v_B = 11.32$ ips. From Equations 62 and 63, $a_B = 4.20$ in./sec² and $a_C = -117.4$ in./sec². Finally, from Equations 67 through 70, $h_D = -0.869$ in., $h_E = -1.131$ in., $v_D = -21.6$ ips, and $a_D = -127.5$ in./sec².

The acceleration equations are:

1. Curve AB,

$$\frac{d^2 y}{dt^2} = 40.9 A_1 + 75.5 A_3 + 4.20 A_5 \quad (71)$$

2. Curve BC,

$$\frac{d^2y}{dt^2} = 48 A_1 + 75.5 A_3 + 4.20 A_4 - 117.4 A_5 \quad (72)$$

3. Curve *CD*,

$$\frac{d^2y}{dt^2} = -107.3 A_1 - 240 A_3 - 117.4 A_4 - 127.5 A_5 \quad (73)$$

4. Curve *DE*,

$$\frac{d^2y}{dt^2} = -139.6 A_1 - 240 A_2 - 127.5 A_4 \quad (74)$$

The displacement equations are:

1. Curve *AB*,

$$y = 0.920 H_1 + 1.698 H_3 + 0.095 H_5 \quad (75)$$

2. Curve *BC*,

$$y = 0.920 + 1.08 H_1 + 1.698 H_2 + 0.095 H_4 - 2.642 H_5 \quad (76)$$

3. Curve *CD*,

$$y = 2.00 - 0.869 H_1 - 1.944 H_3 - 0.951 H_4 - 1.033 H_5 \quad (77)$$

4. Curve *DE*,

$$y = 1.131 - 1.131 H_1 - 1.944 H_2 - 1.033 H_4 \quad (78)$$

The acceleration curve is shown in Fig. 6b.

Pressure Angle

The pressure angle for a cam with a translating on-center roller follower may be calculated from

$$\tan \alpha = \frac{9.55 v_n}{(R + y)N} \quad (79)$$

where α = pressure angle, deg; v_n = velocity of follower at reference point, in. per sec; y = displace-

ment of cam at reference point, in.; R = least radius from cam axis to center of follower, in.; and, N = camshaft velocity, rpm.

In the first example, Fig. 2, assume that the cam is rotating at 200 rpm and $R = 2$ in. From the acceleration curve, Fig. 2b, note that the acceleration changes from positive to negative between points *AB-48* and *AB-54*, very nearly at point *AB-51*. This is the point of maximum pressure angle.

From Equation 22 and Table 1, displacement at point *AB-51* is $y = 0.484$ in.

From Equation 3 and Table 2, the velocity equation for curve *AB* is:

$$\frac{dy}{dt} = 16 V_1 + 25.1 V_3 + 18.28 V_5 \quad (80)$$

Substituting values from Table 2 and solving for the velocity at point *AB-51*, $v_n = 26.5$ ips. From Equation 79, then

$$\tan \alpha = \frac{9.55(26.5)}{(2 + 0.484)200} = 0.509$$

and $\alpha = 27$ deg.

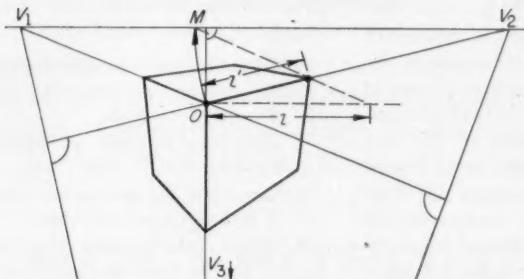
A more rigorous solution would determine the exact point of inflection by letting Equation 4 equal zero and solving for x (coefficient A). Then from Equations 2 and 3, using the x -expressions for coefficients H and V , exact displacement and velocity could be calculated.

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Tips and Techniques

Three-Point Perspective



To lay out three-point perspective accurately without mechanical aids, select the vanishing points so

that the ortho-center, *O* (intersection of perpendiculars from corners to opposite sides) is at the center of vision, usually at the center of the drawing. As shown in the example, it is not necessary that all the vanishing points be accessible.

To measure distances, such as l' , along the line OV_2 , lay off the actual distance, l , parallel to V_1V_2 . The measuring point, *M* is on the line V_1V_2 where $OV_2 = MV_2$. Join point *M* to the terminal point of line l . The intersection of this line on line OV_2 is point l' . Similar constructions are used in other directions.—W. H. SHEPHERD, Montreal, Quebec.

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Progress report on developments in

Explosive Forming

Advanced high-energy process opens up new design possibilities in fabrication of hard-to-form materials and shapes.

As new materials become more readily available, new methods of working them become necessary. Economic methods must be found for joining, forming, machining, and forging the advanced metals. Currently, these problem-metals include: Refractory alloys, high-temperature high-strength alloys, beryllium, titanium, and metals hardened by rolling.

In addition to fabrication problems related to the inherent physical properties, new problems arise out of the need for:

- Larger, more difficult shapes. A recent specification called for a 22-ft diameter hemisphere.
- Difficult-to-form metal sandwiches, such as space-structures and honeycomb.
- Low-volume economical production methods.

New processes being developed to break the producibility barrier include explosive forming—the most advanced of several high-energy techniques. High-energy working of metals refers to controlled methods which apply chemical, pneumatic, or electrical energy to the working of materials by high-pressure impulse shock.

Explosives of two kinds are used to form materials dynamically: Low-order deflagration type, like smokeless powder; and high-order detonating type, like TNT. The low-

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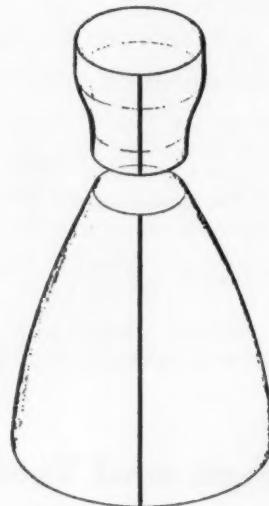


Fig. 1—Difficult-to-spin symmetrical parts that can be readily produced by explosive forming.

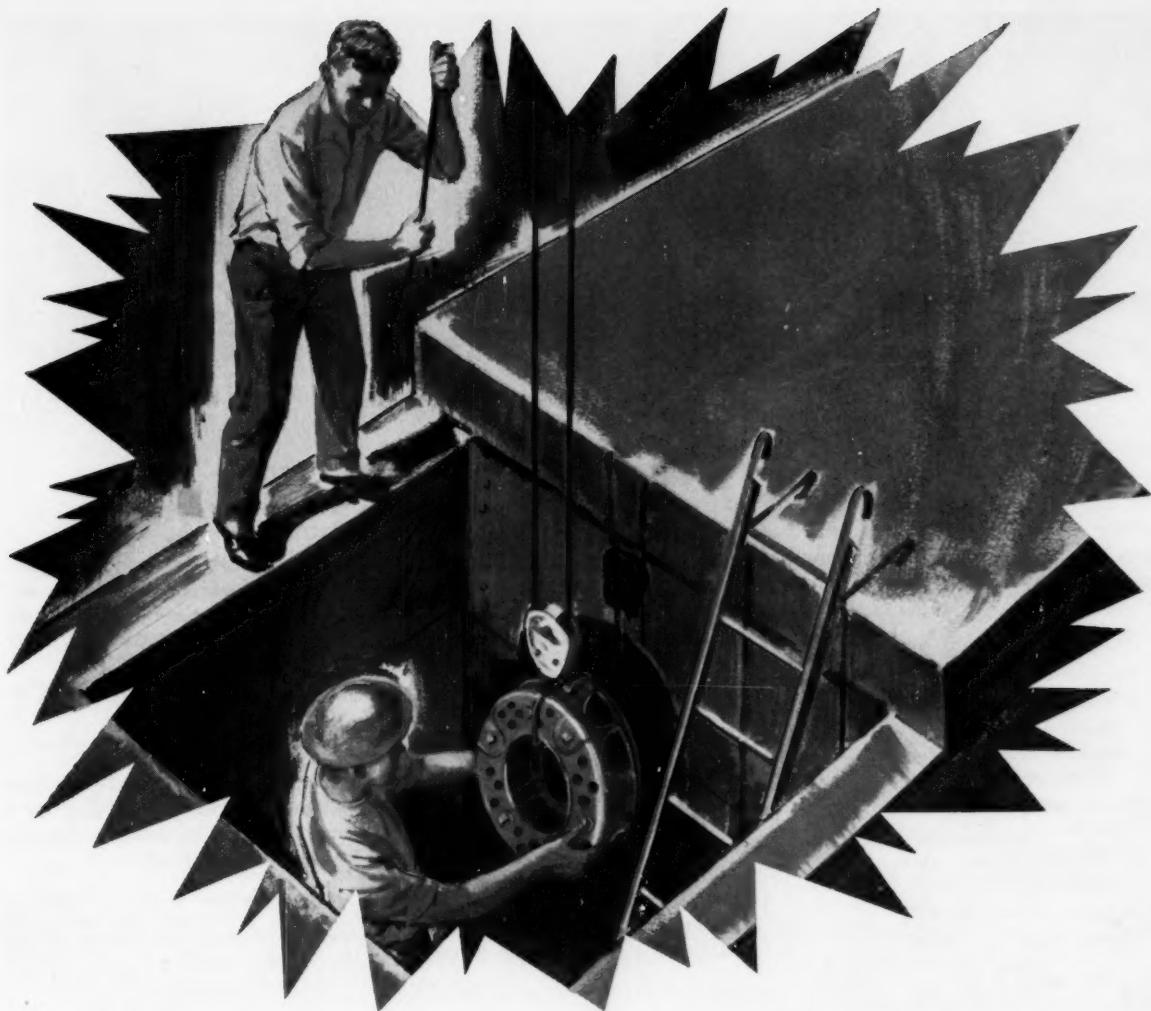
order explosives can attain pressures of 100,000 to 300,000 psi with detonation velocities of hundreds of feet per second. High-order explosives can deliver pressures of one to several million psi at detonation velocities of thousands of feet per second. Although there are different pressure-time relationships for low-order and high-order explosives, the areas under the curves of total energy release are the same for both.

The pulse obtained from a high-order explosive can be varied to include the characteristics between the

two extremes; that is, variation of pressure and duration time. This is possible by:

1. Controlling the expansion pattern of the explosive products, by shaping the explosive charge.
2. Controlling the type and weight of explosive.
3. Controlling the propagation distance of explosive from workpiece.
4. Varying the propagating media, which can be water, air, metal or powder.

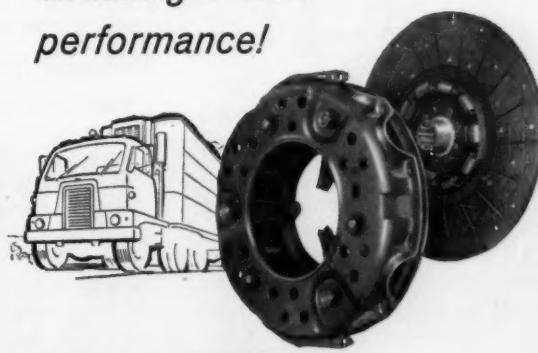
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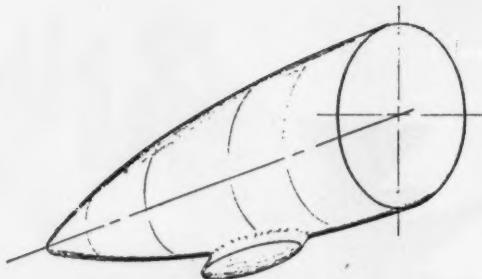
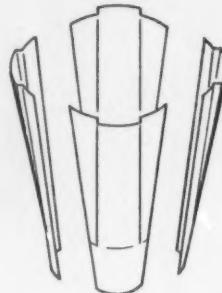
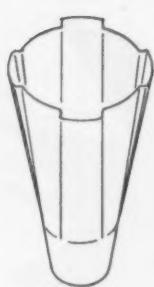


Fig. 2—One-piece assembly forming.

Fig. 3—Difficult necking operation that can be performed with high-explosive processes.

techniques is related to the ability of the methods to form difficult alloys and large parts. At Rocketdyne, materials formed successfully include:

- Aluminum base (2024, 6061-T6)
- Magnesium (AZ31B)
- Iron base, low alloy (4130, 4340, Vascojet 1000)
- Iron base stainless (17-4PH, 17-7PH, 15-7Mo, AM355, 20CB)
- Nickel base (Rene 41, Inconel X, Hastelloy X)
- Cobalt base (HS 21)
- Titanium base (6Al4V, B120VCA)
- Refractory metals (Mo .5Ti)
- Plastics (Kef and Teflon)

Parts range from $\frac{1}{4}$ in. diameter tubing to 5 ft diameter hemispheres. Parts are being made successfully from welded preforms, spun preforms, flat sheet stock, and tubing. In addition to forming parts of increased size, this method is being used to:

1. Form symmetrical parts which are difficult to spin, Fig. 1.
2. Form one-piece assemblies from preforms, Fig. 2.
3. Form unsymmetrical shapes.
4. Combine various forming operations.
5. Preform difficult operations such as necking, Fig. 3.

With explosive forming, the dimensions of products are as good as the dimensions of their dies. Fingerprints left on dies have been reproduced in the part. At the present, tolerances of $+0.000$ and -0.0005 in. are being held in squaring and bulging tubes of 1.000 in. OD.

Parts made by explosive-forming show only minor work-hardening and spring back. Because of the

minimum of work-hardening during explosive-forming, annealing is usually not required.

Explosive-forming has many advantages where high costs, in the absence of other methods, would still make this method attractive; that is, in the area of working tough metals, large, very small, and difficult shapes.

Explosive-forming may have a good or bad effect depending on how well the force is applied and how much consideration is given to the effect of the impulsive load on the material. In addition to normal static-forming properties of materials, consideration must also be given to:

1. Density of material.
2. Effect of high pressure.
3. Effect of plastic-elastic disturbances.
4. Effect of strain rate, yield delay, ratio of dynamic to static yield strength, ductile brittle transition and notch sensitivity.
5. Crystal structure, slippage planes, directional properties.
6. Process condition; microstructure.

In general, if such factors as crystal structure are disregarded, as a metal increases in strength, forming becomes more difficult.

ASME Paper No. 61-AV-13, "Advanced Fabrication Techniques," presented at the Aviation Conference, Los Angeles, March, 1961, 20 pp.

Selection Criteria for Electrical Insulation

GRAHAM LEE MOSES
Westinghouse Electric Corp.

TO aid selection of insulation in electrical components and equipment, this article summarizes requirements and materials.

Mechanical Requirements

Insulation must have satisfactory mechanical strength and physical supports to withstand all the forces that it may encounter during operation. In addition, it must have the strength to withstand the abuse which occurs during fabrication, forming, processing, and installation in the equipment. The more important of the mechanical properties that an insulation should possess are: Flexibility, tear strength, shear strength, flexural strength, tensile strength, bond strength, and abrasion resistance.

Electrical Characteristics

1. Dielectric breakdown strength is the most important electrical property of most insulations.
2. Insulation resistivity must be high so that the insulation is effective.
3. Power factor or dissipation factor is a variable requirement depending upon the end use of the material or apparatus.
4. Dielectric constant may or may not be significant depending upon whether a distorted voltage distribution is important.
5. Corona resistance is always a desirable property, but it is much more important for operation at six thousand volts and above, where corona activity is greater.
6. Arc resistance may be important on some parts.



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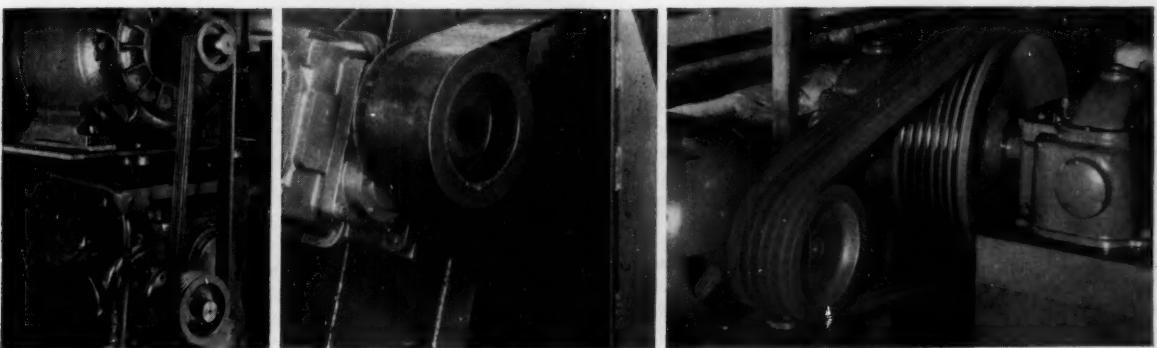
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DESIGN ABSTRACTS

7. Track resistance is desirable where surfaces may be subject to high electric stresses on occasions.

8. Moisture resistance is a highly desirable property in most electrical insulation. Most materials have good electrical properties when dry, but these properties deteriorate rapidly when the surfaces are wet or moisture is absorbed into the solid insulation. The differences in effect of moisture on a material may be a determining factor in the practical selection of the best material, process or design.

Chemical Characteristics

1. Resistance to the common solvents and oils may be of great importance depending upon the end use.

2. Resistance to weak acids and alkalies is a desirable property although the need will be determined largely by the end uses.

3. Ozone degradation is usually the result of corona which is ordinarily of little importance on machines operating below six thousand volts.

4. Flammability is being given more and more emphasis as an insulation requirement.

Thermal Aging Characteristics

Thermal aging is one of the most important characteristics of insulation as this determines the useful service life of the electrical equipment.

Basic Insulating Materials

Cellulose is one of the more common and important forms of electrical insulation. It is used in the form of papers, yarns, cloths and pressboard. Its greatest advantages are low cost, ease of manufacture and absorptive power to permit easy impregnation with an insulating fluid, varnish or resin. Its greatest disadvantages are low thermal stability and tendency to absorb moisture unless well impregnated and sealed.

Asbestos and fibrous glass are somewhat parallel to the cellulosic fibers except that they overcome many of their inherent disadvantages. They have outstanding thermal endurance and mechanical strength and can be processed into a wide variety of papers, yarns, cloths, and boards.

Synthetic resin films and fibers have come into widespread usage in recent years and are overcoming

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many of the disadvantages of the cellulosic structures with which they are analogous. In such resinous sheets and fibers, the nature of the chemical compound determines the important characteristics for electrical insulation material.

Mica is a form of mineral which occurs in the earth in a crystalline structure with preferential orientation of the crystals resulting in thin parallel laminae. The physical structure of the mica provides outstanding electrical and physical properties because the thin laminae are flexible and yet constitutes a dielectric barrier with high intrinsic electric strength and tremendous thermal endurance.

Insulating varnishes provide one of the best methods for easily applying an insulating coating either to individual components or to fabricated structures, such as coils, and to complete windings of electric equipment. These varnishes may be comprised of natural or synthetic resin, usually in a solvent. More recently, tremendous strides have been made in the development of synthetic solventless type resins with low enough viscosity to permit coating, impregnating and casting insulating structures.

When considering the insulating level of materials, it is important to understand that multiple layers of thin dielectric barriers are much more effective than chunks or thick blocks of almost any insulator.

Paper No. 1, "The Purpose of Electrical Insulation," presented in Session 4B, Third National Conference on the Application of Electrical Insulation, Chicago, December, 1960, Conference preprints pp. 112 to 115.

hydraulic

Valve Positioner Design By Dynamic Analysis

Charles B. Schuder, mechanical engineer, Fisher Governor Co.

Application of dynamic analysis techniques to the design of a pneumatic valve positioner. It appears that this application of dynamic analysis offers considerable promise both in improved performance and in reduction of development time. Transfer functions for

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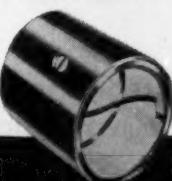
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DESIGN ABSTRACTS

pneumatic components are relatively easy to obtain. In nearly all cases, the basic differential equations are either linear or may be linearized around an operating point. Even where the mathematical model does not exactly represent the components, the design will be close enough to the desired point that only minor modifications will be needed. The use of an analog computer would be desirable, particularly in cases where friction or other nonlinearities are important.

ISA Preprint No. 24-SL-61, "Valve Positroner Design by Dynamic Analysis," presented at the Winter Instrument-Automation Conference and Exhibit, St. Louis, January, 1961, 7 pp.

Pneumatic Actuator Characteristics

Orval P. Lovett Jr., development engineer, E. I. du Pont de Nemours & Co.

Analysis of spring and diaphragm actuators to show how spring rates and diaphragm areas are selected to meet static requirements of air pressure ranges and stem travels. The effects of nonlinearities and variable stem forces on ideal actuator characteristics are discussed. Guides are given for checking the calibration of spring and diaphragm assemblies and for using valve positioners.

ISA Preprint No. 26-SL-61, "Pneumatic Actuator Characteristics," presented at the Winter Instrument-Automation Conference and Exhibit, St. Louis, January, 1961, 5 pp.

Stress Analysis of a Radial-Flow Rotor

M. J. Schilhansl, consultant, Engineering Research and Advanced Product Study Office, Ford Motor Co.

Analysis of the effect of centrifugal forces on a radial-flow rotor. The rotor, consisting of a disk and exactly radial blades, experiences normal stresses in radial and circumferential direction and shear stresses by virtue of centrifugal forces and torque, respectively. The investigation reported here is restricted to the analysis of the effect of the centrifugal forces, primarily because this is the predominant effect at high speeds, at least so long as the rotor is not subjected to torsional vibra-

tions. Special attention is paid to the mutual interference of disk and blades.

ASME Paper No. 60-WA-200, "Stress Analysis of a Radial-Flow Rotor," presented at the Winter General Meeting, New York, November-December, 1960, 7 pp.

materials

Foamed Plastic Particles

Betty Lou Raskin, Radiation Laboratory, Johns Hopkins University

Foamed plastic particles, a new aspect of the fast-growing foamed plastics field. Foamed plastic particles are tiny, discrete, cellular or porous spheres, made of fully polymerized resins. Either open or closed cell in structure, these particles are extremely low in density and can be prepared in controlled sizes ranging from a few to hundreds of microns in diameter. Like foamed plastics in bulk form, these particles can be synthesized from virtually all types of resins and can be tailored to suit end-use requirements.

When dispersed in air, these low density particles are true smokes. That is, they are suspensions of solid particles in a gas.

SPE Paper No. 16-2, "Foamed Plastic Particles—Versatile New Materials," presented at the 17th Annual Technical Conference of the SPE, Washington, D. C., January, 1961, 3 pp.

Fine-Particle Magnets

Fred E. Luborsky, General Electric Research Laboratory

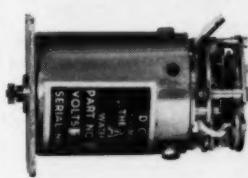
The development of permanent magnet materials and the present state of fine-particle magnets. Also, the present method of preparation and the various theoretical descriptions of the properties of elongated particles are reviewed.

Recent advances in fundamental understanding have resulted in the preparation of elongated iron-particle magnets with energies up to 4.2 million gauss-oersteds and iron-cobalt particle magnets with energies above 6 million gauss-oersteds. The properties of these magnets are discussed.

New work relates the parameters of preparation to the resulting di-

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DESIGN ABSTRACTS

ameter of the elongated particles. Thus, by controlled electrolysis into mercury, the diameters of elongated iron-cobalt particles were varied from about 100 to 350 angstroms without changing their relative structure and elongation. Rotational hysteresis, coercive force, and coercive force as a function of orientation were studied and found to be relatively invariant over this change of diameters. This observed behavior is compared to various theoretical descriptions.

Paper No. 66, "The Development of Fine-Particle Magnets," presented at the Sixth Annual Conference on Magnetism and Magnetic Materials, New York, November, 1960.

Time-Dependent Rupture of High-Impact Thermoplastics

J. V. Schmitz and R. S. Hagan, General Electric Co.

Investigation of large differences in the time-dependent rupture properties of rubber-reinforced thermoplastic materials. Some insight into the differences may be gained by study of static tensile behavior. However, very little knowledge of the time-dependent properties of thermoplastics can be obtained from information from material suppliers. Some understanding can be obtained from relatively short time tests at high stress levels.

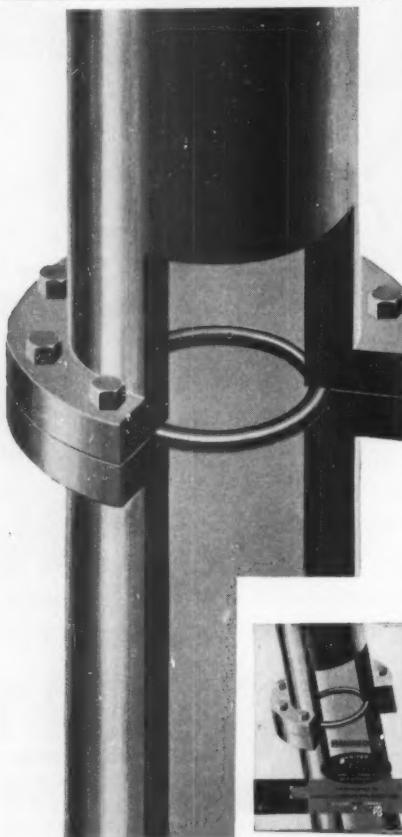
Creep, creep-rupture, environmental stress-cracking, and fatigue depend on the interaction of properties of resin and rubber, and on resin-rubber adhesion. These differ through subtle changes in polymer structure, including: Molecular weight and molecular weight distribution; rubber particle size, form and gel level; and individual chemical compositions.

SPE Paper No. 17-2, "Time-Dependent Rupture of High-Impact Thermoplastics," presented at the 17th Annual Technical Conference of the SPE, Washington, D.C., January, 1961, 7 pp.

Properties of Thin Ferrite Films

E. Banks, N. H. Riederman, H. W. Schleuning, and L. M. Silber, Polytechnic Institute of Brooklyn

Thin films of ferrites, of the order of 1000 angstroms thickness, pre-



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*Patents 2,809,269; 2,837,360

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pared by vacuum evaporation of the metals, and subsequent high temperature oxidation. Films of iron, nickel, cobalt, magnesium, and copper ferrites, mixed ferrites and mixed ferrite-aluminates, as well as yttrium-iron garnet, have been prepared.

In many respects, the properties of the films are the same as those of bulk ferrites of similar composition. The resistivity of the films can be controlled by proper oxidizing procedures. Resonance measurements indicate that the saturation magnetizations of the films are comparable to those of the corresponding bulk ferrites, although the films show larger resonance line-widths.

It has been possible to prepare magnesium ferrite films with magnetizations from 2200 gauss to less than 500 gauss by proper annealing and quenching. The possible advantages of thin films are that they allow optical studies of the material by transmission, and should permit determination of magnetic exchange constants.

Paper No. 14, "Preparation and Properties of Thin Ferrite Films," presented at the Sixth Annual Conference on Magnetism and Magnetic Materials, New York, November, 1960.

Designing with High-Density Polyethylene

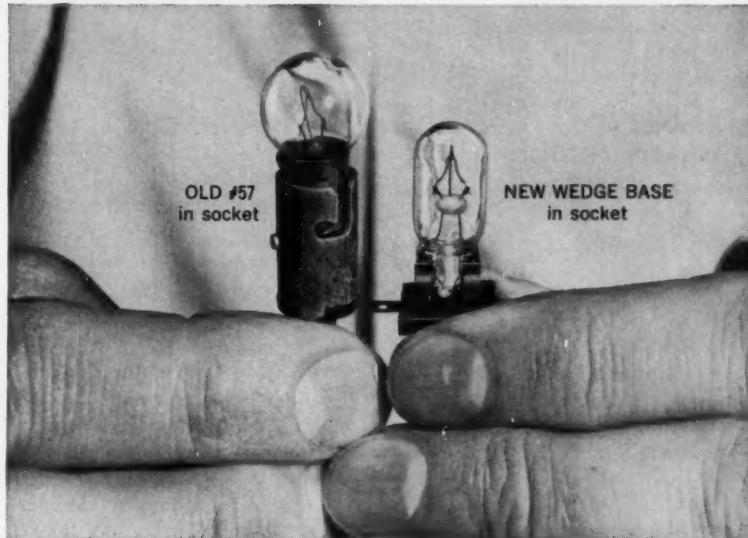
J. V. Smith, C. G. Williams, and L. R. Alexander, Phillips Chemical Co.

Proper design of parts to be made of high-density polyethylene. Studies of molded items show that some concepts of part design which were used for other materials are unsatisfactory for high-density polyethylene. For example, to increase rigidity in a part the walls have often been tapered from thin at the bottom to thicker at the edge. When high-density polyethylene is used, a slightly thicker wall in the gate area with uniform wall thickness throughout the part, or a slight thinning toward the edges, has proved to be best. A thicker section in the gate area improves the ease of fill and reduces orientation that is conducive to brittleness and distortion.

If additional rigidity is required, it is preferable to change the geometry of the part rather than the wall



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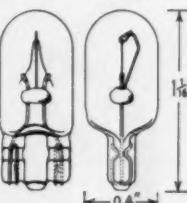
The new "Wedge Base", all-glass, incandescent indicator lamp is an exclusive G-E development designed to replace the old #57 and other similar bayonet-based lamps. It's available in 6.3 and 12 volts. See below.

The Wedge Base saves space because, with its holder, it is considerably smaller than the old #57. It saves money because the holder and total installation costs are less. It saves time because the holder is easier to install and the lamp can be seated with just a push. And it saves manpower because installation can be automated and holders can be molded into plastic circuits. The G-E Wedge Base lamp can withstand ambient temperatures up to 600°F because it has no basing cement.

A major automobile manufacturer is already using G-E Wedge Base lamps; they're available in mass quantities. For more information write: General Electric Co., Miniature Lamp Department M-12, Nela Park, Cleveland 12, Ohio.

The Wedge Base is available in two ratings

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Circuit Volts	12	6.3
Amperes	0.24	0.15
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at design volts	500 Hrs.	*
Filament	C-2V.	C-2R
L.C.L.	1/2"	1/2"
Bulb	T-3 1/4	T-3 1/4
Base Type	Wedge	Wedge
Candlepower	2	.35
*In excess of 5000 hrs. at 6.6 volts		



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thickness. The double stepped edge is very effective and can be used quite well with an item that has a lid. These steps, or changes in plane, need not be very large. Even a step no greater than the wall thickness of the part is very helpful. Steps also help to disturb the flow of material along the cavity and to spread out the advancing front so that the cavity is filled uniformly.

SPE Paper No. 11-4, "Molding High-Density Polyethylene in Large Boxes, Trays and Lids," presented at the 17th Annual Technical Conference of the SPE, Washington, D. C., January, 1961, 3 pp.

Hardness of Polymeric Materials

Eric Baer, R. E. Maier, R. N. Peterson, E. I. du Pont de Nemours & Co.

How the results of hardness tests can be interpreted in terms of the basic stress-strain behavior of the material.

When a ball indenter presses onto a metal surface, the material first deforms elastically. As the load is increased, the stresses soon exceed the elastic limit and plastic flow starts. By increasing the load still further, the material directly beneath the penetrator becomes completely plastic and the metal is permanently displaced. A similar approach has been used to study the hardness of polymers, although in parts the theory had to be modified to account for differences in the

mechanical behavior.

Discussion is divided into two parts. First, the indentation process is considered when large loads are placed on the penetrator and the material beneath the indenter becomes permanently displaced. Second, the recovery process which occurs immediately after the load is released has been defined and analyzed in terms of certain elastic concepts.

SPE Paper No. 17-4, "Hardness of Polymeric Materials," presented at the 17th Annual Technical Conference of the SPE, Washington, D. C., January, 1961, 3 pp.

electrical

Thermal Design for Microminiaturized Circuitry

H. C. Kammerer, Federal Systems Div., International Business Machines Corp.

Thermal design as an initial consideration, based on techniques which permit the fabrication of circuits with a theoretical packing density of 1 million or more circuits per cubic foot. In most cases the drive toward microminiaturization is based on the need for a large number of circuits in a small weight and volume. If present circuit designs are taken as the basis for microminiaturization, it can be shown that with most materials being considered the temperature will rapidly rise to the point where circuits will become inoperative.

This paper outlines some of the basic considerations in terms of heat conductivity of materials, maximum safe working temperatures, and circuit power levels as dictated by current devices. A method is described whereby a proposed design configuration can be computer-analyzed in terms of isothermal lines and maximum hot-spot temperatures.

ASME Paper No. 61-AV-5, "Thermal Design for Microminiaturized Circuitry," presented at the Aviation Conference, Los Angeles, March, 1961, 7 pp.

mechanical

Application Factors in Small Turbocharger Design

John M. Cazier, senior project engineer, and Wolfgang S. Lang, senior development engineer, AiResearch Industrial Div., The Garrett Corp.

Factors influencing small turbocharger design and some techniques used in their development. In the first section, specific techniques used in developing turbocharger journal bearings and rotors are discussed. The influence of engine application upon turbocharger aerodynamic design requirements is discussed with examples in the second section.

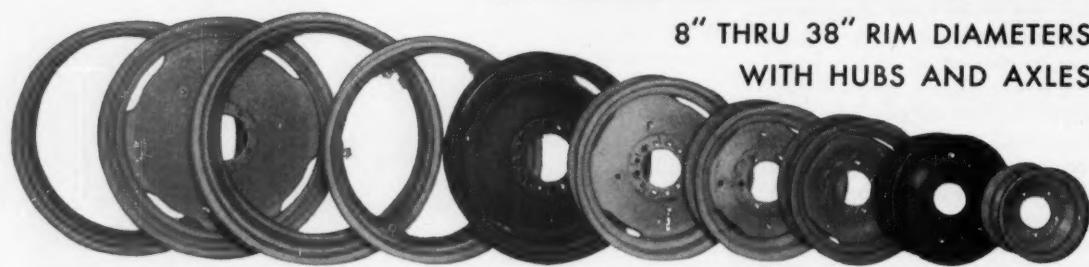
The objectives and techniques of small turbocharger development are greatly influenced by two important characteristics of the turbocharger market.

1. The turbocharger has become an in-

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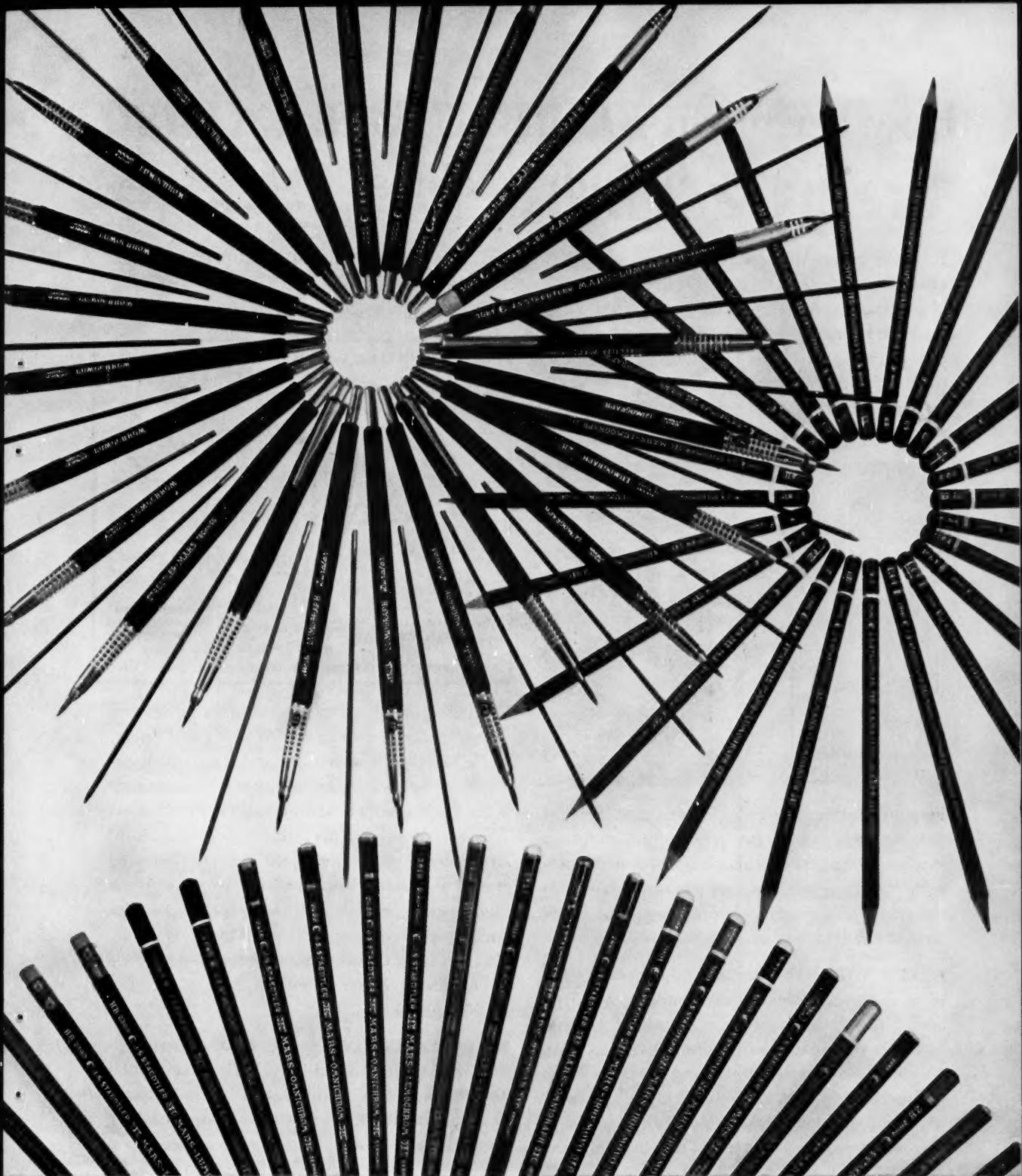


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DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY
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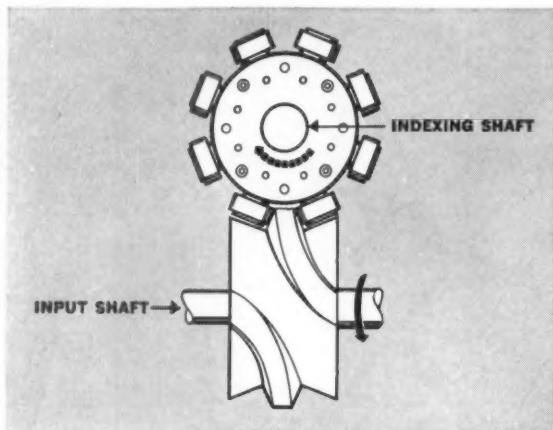
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How Ferguson *ELIMINATES BACKLASH* in Index Tables

Backlash in indexing results in shock loads that affect the efficiency of a machine and the quality of its product. Most indexing mechanisms have inherent characteristics that cause backlash and poor dynamic conditions and prevent the designer from taking full advantage of modern feeds, tooling and methods that contribute to production economy.



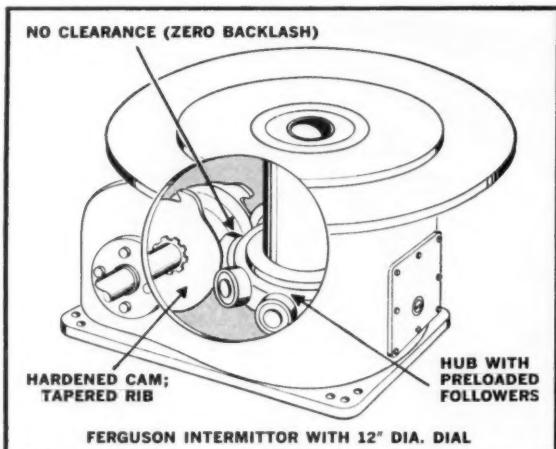
Ferguson Intermittor Index Tables have inherent zero backlash and extreme precision which results in a rotary transfer machine base capable of operating speeds up to 500 indexes a minute. *A Ferguson index table never proves to be a limiting factor in the speed or performance of an automatic assembly machine.*

HERE'S WHY: The continuously rotating cam of a Ferguson indexing mechanism features a *tapered rib* along which two preloaded bearing followers roll, maintaining constant contact with no clearance between them and the rib. When the mechanism is in the rest, or dwell, position, a straight portion of the rib locks the followers



with zero backlash and an indexing accuracy of $.001"$. Wear on the hardened tool steel cam is infinitesimal (many have been in use for more than 25 years). Followers are rated for a minimum of 8,000 hours opera-

tion. If backlash occurs after this period the life of the drive may be renewed merely by replacing the standard followers.



Compare this with other types of indexing devices. A geneva drive, with its slotted wheel and driver, and a barrel cam with a grooved track which engages one follower at a time, must have clearance in the slot or groove to allow passage of the follower. The slightest amount of clearance causes backlash. As the slot or groove wears, the clearance becomes greater and the backlash condition worsens. At the higher, more profitable operating speeds poor dynamics cause wear on other parts of the machine. The user must choose between frequent downtime for repairs or slower speeds . . . He is the loser in either case.

FREE DESIGN DATA — Load ratings, dimensions and application and installation information about standard and stock Intermittors, Ferguson Drives and in-line machines are contained in a single 36 page catalog. Every designer should have one in his library . . . Write Ferguson—Ask for Catalog No. 160.

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creasingly intimate part of the engine's thermodynamics.

2. A considerable range of airflow capacities and characteristics can be fitted into a given basic turbocharger frame.

As a consequence, the aerodynamics of the turbocharger are becoming increasingly tailored to the application, and the mechanical parts of each turbocharger frame are being applied to a large number of different applications.

SAE Paper No. 257B, "Developing the Turbocharger for Its Application," presented at the SAE National Powerplant Meeting, Cleveland, October-November, 1960, 11 pp.

techniques

Bending of Cylinders by Radial Shear Forces

Paul Seide, Space Technology Laboratories Inc.

The effect of discontinuous circumferential end loading of a circular cylinder by equal and equally spaced radial shear forces and moments. Large nonuniform bending effects are found for combinations of circumferential load coverage and cylinder geometry for which an assumption of uniform loading might intuitively be expected to be adequate.

ASME Paper No. 60-WA-32, "On the Bending of Circular Cylindrical Shells by Equal and Equally Spaced End Radial Shear Forces and Moments," presented at the Winter Annual Meeting, New York, November-December, 1960, 10 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

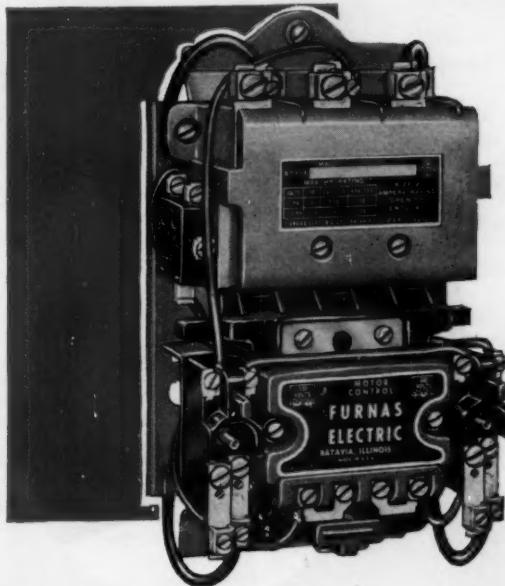
ISA—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

SPE—Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn., papers 25 cents to members, 40 cents to nonmembers.

Sixth Annual Conference on Magnetism and Magnetic Materials, sponsored by the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., and the American Institute of Physics, 335 East 45th St., New York 17, N. Y.

Third Annual Conference on the Application of Electrical Insulation, sponsored by the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., and the National Electrical Manufacturers Association.

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Furnas Firsts

For many years Furnas Electric has pioneered development of outstanding magnetic control features that are now used extensively throughout the motor control industry. Among "Furnas Firsts" are the outstanding features listed below.

TRULY TRIP-FREE THERMAL OVERLOAD RELAYS—melting alloy type. Non-adjustable trip features assure tamper-proof operation.

ENCAPSULATED DUAL VOLTAGE COILS—greater heat dissipation, and greater mechanical strength. 110-220 or 220-440 volts.

IN-BETWEEN SIZES—provide wider selection of controls to match your motor requirements, effecting savings in cost and space.

AUXILIARY SWITCHLETS—offer easy means for adding auxiliary circuits to the starter at any time.

PRESSURE OPERATED MAGNETIC STARTERS—a single unit offering pilot control for pneumatic and hydraulic systems, eliminating unnecessary wiring and piping.

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ANOTHER LING FIRST! NEW 5000 LB. SHAKER —PROVIDES BUILT-IN PIGGY-BACK CHAMBER CAPABILITY

Ling offers you another design first with its new Model 300 Shaker. This new 5,000-pound-force shaker features Ling's unique closed-loop water-cooling system, a hermetically sealed system which is specifically designed to eliminate coolant contamination of an environmental chamber. Without any special shaker accessories, it operates with a piggy-back chamber, permitting testing to unlimited altitudes and humidity, and at temperatures from -100° to $+300^{\circ}\text{F}$. The specially designed lightweight armature weighs only 41.5 lbs. Ling's unique low-voltage armature and field design eliminates corona problems when operating at altitudes, and the temperature range can be readily expanded above 300°F with the addition of an external thermal barrier. For details on Model 300, write Department MD-461 at the address below.



LING-TEMCO ELECTRONICS, INC.

LING ELECTRONICS DIVISION

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Circle 314 on Page 19

LING ELECTRONICS

The design of the Model 300 Shaker is an extension of an environmental shaker concept pioneered by Ling. This revolutionary concept, using a closed-loop cooling system for direct cooling of the armature, field coils and for compensation conductors, has greatly improved the efficiency of shaker performance.

In Model 300, Ling hermetically seals the system—so the standard shaker can be used freely in an evacuated chamber without special shaker accessories. Model 300 is particularly suited for mounting with the piggy-back chamber—the technique in which the shaker body acts as one wall of the chamber, and only the table rides into the chamber.

In addition, Model 300 offers Ling's new velocity signal generator for displacement monitoring. Loop-type flexures offer maximum lateral restraint and linear spring constant.



SPECIFICATIONS FOR LING'S MODEL 300 SHAKER INCLUDE:

Force Rating; vector	5,000 lbs.
Frequency range	5-3,000 cps.
Stroke, continuous duty...	
Flexure Stiffness	1,000 lbs. per inch
Table Diameter	13½ inches
Max. Acceleration	100 G
Stray Field	less than 6 gauss, 3 inches above the table



LING-TEMCO ELECTRONICS, INC.
LING ELECTRONICS DIVISION

HIGH POWER ELECTRONICS FOR
VIBRATION TESTING • ACOUSTICS • SONAR

Helpful Literature for Design Engineers

For copies of any literature listed,
circle Item Number on Yellow Card—page 19

Stamped Gears

Catalog 6011 covers a broad line of stamped gears. Tables give specifications for all sizes of stamped gears, segments, internals, ring gears, crown gears, sprockets, and ratchets. Further data are incorporated on center hole shapes, tooth parts, diametral pitch rules, and formulas for spur gears. 16 pages. Winzeler Mfg. & Tool Co., 7355 W. Wilson Ave., Chicago 31, Ill.

Circle 601 on Page 19

Spring-Tension Fasteners

Summarized in new brochure are the various classes of spring-tension fasteners. Illustrations show customized designs for clamps, clips, latches and locks, pins, retainers, snap rings, hooks and holders, catches, spring washers, hangers, and collars. Case-history examples demonstrate how spring-like flat stampings simplify design, cut costs, and improve reliability. 4 pages. Associated Spring Corp., Bristol, Conn.

Circle 602 on Page 19

Silicon Rectifiers

Illustrated in color, Bulletin 300 gives electrical and mechanical specifications for line of certified silicon rectifiers and stacks. It also includes a list of more than 350 JEDEC types of silicon rectifiers produced. Cutaway drawings are included to show construction features. Condensed electrical and mechanical specifications are given, as well as typical operating characteristics through the use of curves. 6 pages. Semiconductor Div., Syntren Co., Homer City, Pa.

Circle 603 on Page 19

Advanced Materials

"Materials for Advanced Technology" presents data on 12 new products. Materials described provide opportunities for improved design and performance in applications requiring resistance to abrasion, chemicals, corrosion, nuclear radiation, and high temperatures. 8 pages. Dept. BMD, Carborundum Co., P. O. Box 337, Niagara Falls, N. Y.

Circle 604 on Page 19

Adjustable-Speed Drives

RectiFlow and MagnaFlow adjustable-speed drives for pumping applications are discussed in Application Data Booklet 5560. Booklet presents an informative drive-selector guide for many industries. It is illustrated with application diagrams,

efficiency curves, and mechanical features of both types of adjustable-speed drives. 8 pages. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 605 on Page 19

Laboratory Oscilloscopes

New booklet gives a detailed presentation of eight available complete-unit oscilloscopes. Four units measure applications from dc to 450 kc, one from dc to 1 mc, and three from dc to 15 mc. Booklet contains specifications, performance characteristics, and pertinent illustrations for single-beam, dual-beam, dual-trace, and rack-mount models. 20 pages. Tektronix Inc., P. O. Box 500, Beaverton, Oreg.

Circle 606 on Page 19

High-Speed Computing System

Bulletin QC-020-R110 on the G-20 high-speed computing system details outstanding operational features, and includes data on improvements in computing, magnetic tape, and line printer speeds. Booklet also describes increased memory and processing facilities of the control buffers and communication system. Basic, medium, and large systems are shown. 18 pages. Bendix Computer Div., Bendix Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Circle 607 on Page 19

Aircraft Hydraulic Filters

Bulletin A7 describes aircraft hydraulic filters made to the requirements of Specification MIL-F-8815. Bulletin contains drawings, technical data, and ordering information for this series of filters which incorporate Supramesh two-stage filter elements. Photographs and drawings of this and other features are included. 8 pages. Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

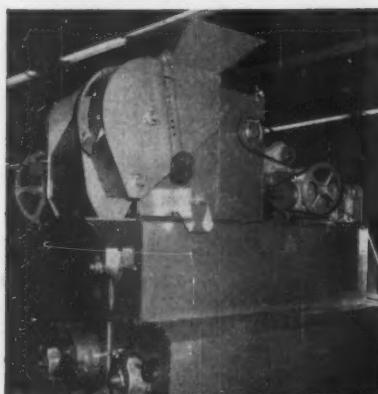
Circle 608 on Page 19

Temperature Controls

Brochure MC-195 describes new 500-Line temperature controllers and indicators. Brochure gives complete details of three models in the line, and includes brief descriptions of other instruments offering thermistor sensing. Contents include complete electrical and mechanical specifications, available modifications, and illustrated descriptions of various major features of the units. 8 pages. Fenwal Inc., Pleasant Street, Ashland, Mass.

Circle 609 on Page 19

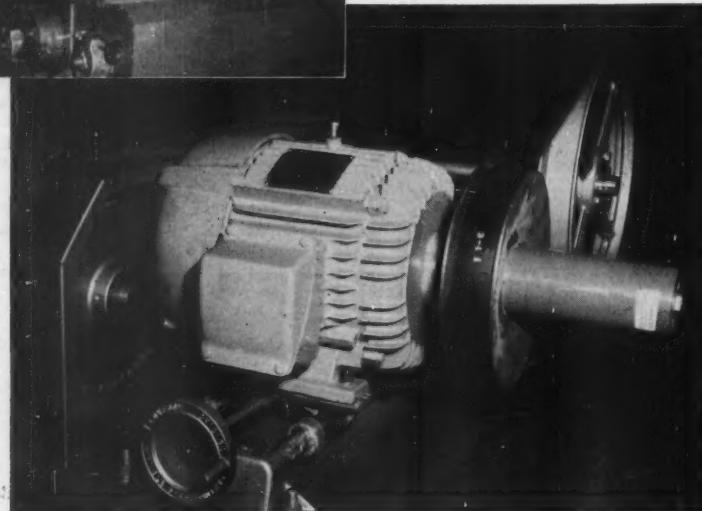
Why Lovejoy Vari-Speed Equipment Drives This Precision Processing Machine



Known as the "Dominion Minor", this grain processing machine* is a multi-cylinder unit which scalps, aspirates and makes five clean cut separations on all types of grain.

Lovejoy Vari-Speed components used are:

No. 3050 5-hp. Variable Speed Pulley
No. 720-18 Belt and
No. 18 Drive Sheave
No. 303-C Motor Base



... for accuracy and great flexibility

"Cleaning and grading grain for seed is an exacting process which requires a machine of great accuracy and flexibility," the manufacturer reports. "To assure maximum accuracy and flexibility we use Lovejoy Vari-Speed Components on our new multi-cylinder machine."

... for quality, service and price

We also chose Lovejoy Vari-Speed Components because of quality, service and price. Our new machine has stood the test of heavy duty field service with no problems whatsoever."

Lovejoy's full line of vari-speed equipment includes variable speed pulleys, variable speed transmissions and bases for all NEMA frame sizes. Why not request recommendations for your application? Ask for catalog 61-B for general information. Also ask for literature on flexible couplings, universal joints and shaft mounted gear reducers.

*Name of manufacturer on request

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Circle 315 on Page 19

HELPFUL LITERATURE

Connector Protectors

Rectangular plastic protectors for miniature electronic pin connectors are described in Bulletin P-6012. Twelve cap sizes fit MIL-C-8384 connectors, both flanged and unflanged. Complete dimensions, weights, and prices are detailed. 4 pages. Dept. WLT, Plastics Div., S. S. White Industrial Div., 10 E. 40th St., New York 16, N. Y.

Circle 610 on Page 19

Retaining Rings

Catalogs 30 and 31 describe industrial prestacked internal and external retaining rings axially applied. Each catalog contains all pertinent data, using tables and line drawings. 4 pages each booklet. Industrial Retaining Ring Co., 57 Cordier St., Irvington 11, N. J.

Circle 611 on Page 19

Centrifugal Pumps

New single-stage centrifugal pumps are described in Bulletin 725.8. Bearing life, shaft deflection data, and a frame-selection chart are incorporated. Performance, specifications, construction details, and dimensions are also detailed in charts, section drawings, and tables. 16 pages. Goulds Pumps Inc., 220 Black Brook Rd., Seneca Falls, N. Y.

Circle 612 on Page 19

One-Piece Metal Enclosures

Data Sheet F 10412 describes the design advantages of Polyform, a method of forming metal enclosures in one piece. Enclosures can be shaped in any configuration to give design freedom. Data sheet includes information on shapes, materials, strength, electromagnetic shielding, size, tolerances, and machining characteristics. 2 pages. Barber-Colman Co., Rockford, Ill.

Circle 613 on Page 19

Push-Type Insert

Bulletin 777 describes how the push-type Heli-Coil insert is used to form strong threads in plastics after molding. Insert is retained in the part by a slight interference fit, and strength of the assembly is determined by the strength of the shoulder against which the insert is installed. Table lists sizes, dimensions, and prices. Additional information covers hole size, tools for installing the insert, and availability of application assistance. 2 pages. Heli-Coil Corp., Danbury, Conn.

Circle 614 on Page 19

Transistor Transformers

Catalog Supplement 2 provides data on tiny transistor transformers known as Buds and Mites. Features of both units are given, and tables list pertinent characteristics. Curve of frequency response is included. Dimensional drawings of the two units are also provided. 4 pages. Decco Inc., 2025 Farrington, Dallas 7, Tex.

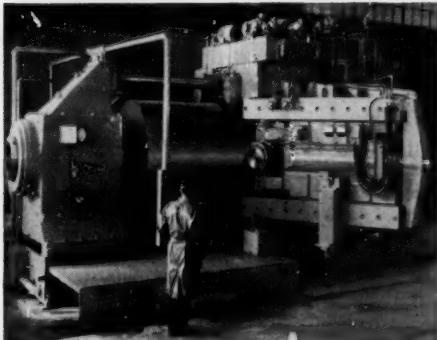
Circle 615 on Page 19

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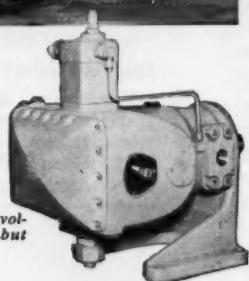


How **LOGGE & SHIPLEY** get
smooth, variable feed control
with **DENISON** hydraulic power
on new machine designed for...

SHEAR FORM



SHEAR FORMING MISSILE SECTIONS up to 70" in diameter, 140" long is done on new 190,000 lb. **FLOTURN®** machine made by The Lodge & Shipley Co., Cincinnati. Denison Series 800 Variable Volume Piston Pump (shown at right with pressure compensator control) varies output volume to maintain fixed, but adjustable, pressure.



HERE'S ONE of the largest horizontal shear forming machines ever built. This 150 hp giant was developed by Lodge & Shipley to handle the tough metal forming job of flowing ultrahigh-strength forged steel rings into rocket cases for the Minuteman ICBM. Their new FLOTURN® machine does the work faster than the previous method... saves materials, too.

Lodge & Shipley designers faced this key problem: how to provide variable feed control of all carriage movements without use of gears or belts. High efficiency and low heat conditions were additional drive system requirements.

Solution: Denison hydraulic power. 28 Denison hydraulic components—variable volume pumps, motors, valves and controls—are employed in the four separate hydraulic circuits supplying power to the carriage, two roller slides and tailstock. Each movement is individually controlled and infinitely variable. The smooth, positive action of Denison hydraulic power gives *high precision control* for holding the specified close tolerances.

This is the kind of problem your Denison Hydraulic Specialist can help you solve. Working with you at the design stage, he can show you how Denison hydraulic power can help break engineering bottlenecks, improve your product and cut costs. Get in touch with him now.

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* In manufacturing woven felts used in papermaking, singeing is sometimes necessary to remove excess wool nap. But then the problem arises: how to remove the singe dust—evenly, smoothly, and without affecting color and texture of the felt.

Machinery and Equipment Development Engineers and Purchasing at the Huyck Felt Co. in Rensselaer, New York found the answer. Working with Spencer people, they developed a system which . . . operating through a "floating" pick-up tube (as shown above) . . . utilizes vacuum to do the job—cleanly, precisely, quickly.

Perhaps vacuum can help solve your unusual design problem. We'll be glad to offer suggestions—at no obligation.



Request Catalog No. 155B,
"Spencer Vacuum"

The **SPENCER**
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HELPFUL LITERATURE

Metallic Static Face Seals

New catalog illustrates and describes complete line of metallic static face seals designed to meet high pressure and temperature requirements in missiles and high-performance aircraft. It describes and lists HS series seals, presents detailed design, material, and application information for use of the seals in valves, actuators, couplings, filters, missile and rocket engines. Dimensional drawings are included. 4 pages. Haskel Seals Div., Haskel Engineering & Supply Co., 1236 S. Central Ave., Glendale 4, Calif.

Circle 616 on Page 19

Corrosion Guide

New corrosion guide analyzes seven basic types of corrosion and shows what kinds of metals best resist them. Chart lists 136 types of corrosive agents and shows the resistance of each of eight types of metals to them. Another chart is a cross-index of chemically equivalent specifications of metal fasteners. Each metal and alloy used in company's fasteners is described with notes on characteristics, uses, and chemical and mechanical properties. 24 pages. H. M. Harper Co., Morton Grove, Ill.

Circle 617 on Page 19

Self-Aligning Bearings

Catalog 551 covers entire Monoball line of self-aligning and rod-end bearings. Included are new Dyflon plastic-alloy-insert, self-lubricated units. Tables and dimensional drawings are incorporated for each unit. 56 pages. Southwest Products Co., 1705 S. Mountain Ave., Monrovia, Calif.

Circle 618 on Page 19

Thermoplastics Properties

Pocket-sized thermoplastics comparison chart gives mechanical and electrical properties of Lexan, Delrin, Zytel 31, Zytel 101, and Imprex A. The ASTM test method for each property is shown. Printed on cardboard, chart is suitable for wall hanging. 4 pages. A. L. Hyde Co., Grenloch, N. J.

Circle 619 on Page 19

Drafting Film

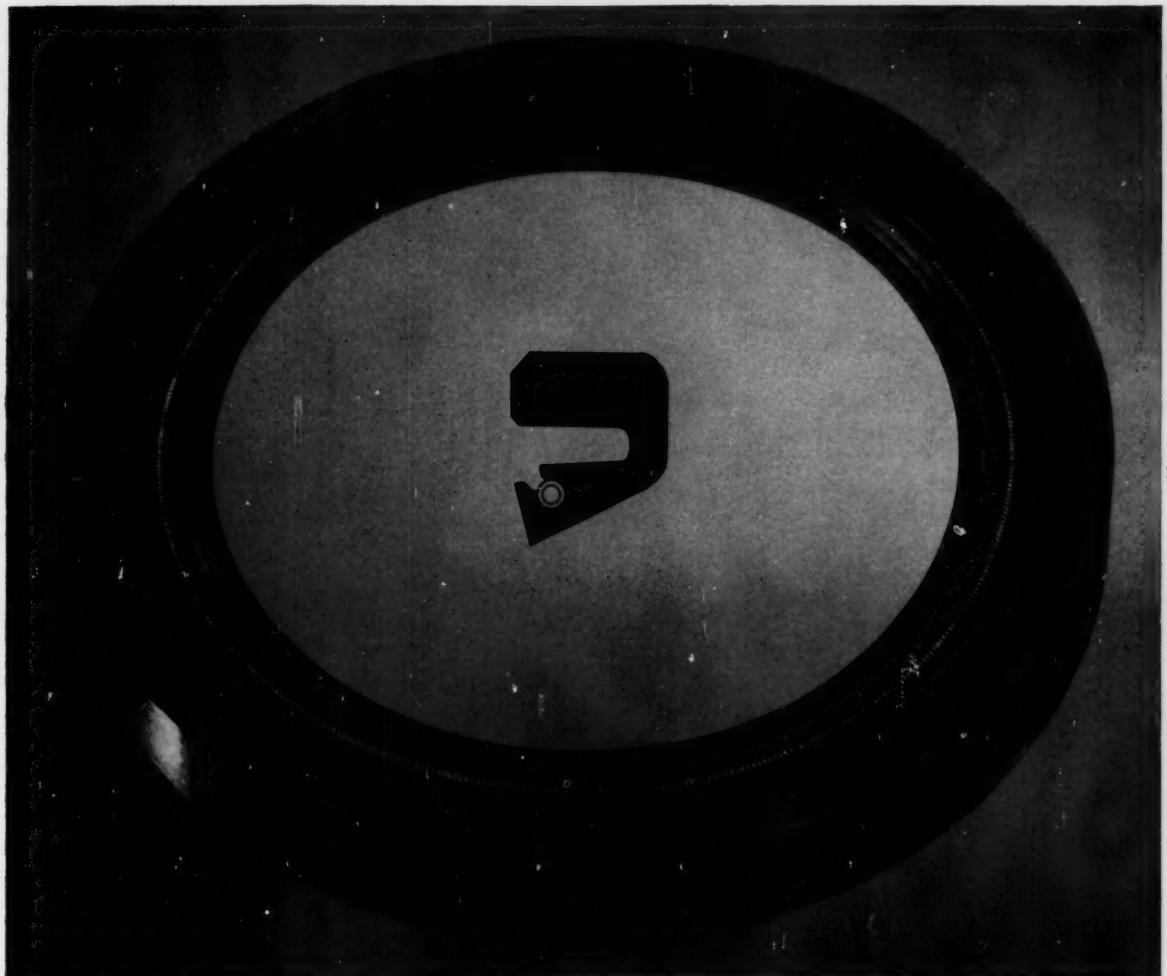
New line of Ark-A-Tex drafting film is shown in a sample folder. Data on the product, its performance, and reproduction are incorporated. Film is available in white or blue, single or double matte, and in sheets or rolls. Arkwright Finishing Div., Arkwright-Interlaken Inc., Fiskeville, R. I.

Circle 620 on Page 19

Adjustable-Speed Belts

Interchange guide lists outside circumference, top width, and number of links of Manheim adjustable-speed belt required for equivalent sizes of other rubber belts, and for wood-block belts. Data on how to measure and install Types I through V MVS belts are included. 8 pages. Manheim Mfg. & Belting Co., Manheim, Pa.

Circle 621 on Page 19

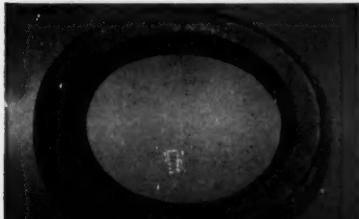


Tame corrosion with J-M Clipper® Seals!

Their all-compound construction

- prevents rusting in the cavity
- provides better bearing protection
- simplifies removal and replacement

The two pictures on this page dramatically demonstrate the importance of an *all-compound* construc-



Metal-cased Seal will rust and corrode

tion where corrosives must be reckoned with. The Clipper Seal shown above has seen service in a severe application. Yet unlike seals of other than all-compound construction, it has come away unharmed and still fit for further service. *Nothing* in a Clipper Seal can rust, or corrode in the cavity, or cause pitting of bore surfaces. In the styles using a garter ring, even the spring is made of stainless steel!

A Clipper Seal consists of a soft, flexible lip and a tough, dense asbesto-compound heel, concentrically moulded into one unit. The heel effectively protects the bore from dam-

age, and you'll never need to scrape or refinish the bore surfaces. Clipper Seals come away clean and easy... replacement is fast and requires no special tools or adhesives. And for quick, temporary replacement, Johns-Manville produces a special split seal.

Let your J-M Distributor help you select the *right* seal for your service conditions from the wide range of designs, compounds and durometer stocks available. Or for a copy of helpful book PK-71A, write to Johns-Manville, Box 14, New York 16, N.Y. Cable address: JOHNMANVIL. In Canada, write to Port Credit, Ont.

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AC MOTORS

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MODEL "B" FOUR POLE, FOUR COIL, SHADED POLE MOTOR

Designed for long life and dynamically balanced for extremely quiet operation. Self aligning, self lubricating bronze bearings. Baked varnish unpregnated windings, ample oil reservoir located for easy lubrication. Smooth, quiet, field-proven.

SPECIFICATIONS

MODEL	HP	Locked RPM	Max. Torque in./oz.	Free Speed in./oz.	Wt. Lbs.
B-5-CW	1.80	3.5	11	1735	2.0
B-5-CCW					
B-8-CW	1.50	4.0	14	1750	2.7
B-8-CCW					
B-10-CW	1.40	4.7	18	1750	3.1
B-10-CCW					
B-12-CW	1.35	4.7	20	1760	3.4
B-12-CCW					

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Circle 319 on Page 19

208

HELPFUL LITERATURE

Metallic Seal

Advanced Pneuflex seal, designed specifically to meet high-pressure and extreme-temperature requirements of system components, is described in new bulletin. Described in detail are seal characteristics and their design and function. Detail drawings show seal applications in both typical and special installations. Also included is a section of engineering design data and recommended machining specifications. 8 pages. Del Mfg. Div., Arrowhead & Puritas Waters Inc., 1584 E. 20th St., Los Angeles 11, Calif.

Circle 622 on Page 19

Adjustable-Speed Belts

Catalog 61-C provides data on a complete line of sizes and types of belts for industrial applications. List of standard belt sizes (nominal) is provided. Change-over guides are given by device manufacturer and by belt manufacturer. Data on Adjusta-Link adjustable-speed belting are included. 14 pages. Lovejoy Flexible Coupling Co., 4945-4949 W. Lake St., Chicago 44, Ill.

Circle 623 on Page 19

Potting Compound

Bulletin CDS-280 describes LTV-602 clear silicone potting compound which provides mechanical and dielectric protection for electronic components and assemblies. Bulletin lists complete properties of the compound and outlines procedure for preparing it for use. Publication is illustrated with many photographs. 4 pages. Silicone Products Dept., General Electric Co., Waterford, N. Y.

Circle 624 on Page 19

Miniature Panel Meters

New catalog of miniature panel meters, side indicators, and other miniature components is now available. Included are a line of subminiature 1-in. diam meters, a line of 1 1/2-in. diam meters, and a variety of side-indicator panel meters with external zero adjustment at the front. Also featured is Model 2547 electronic control meter. Catalog includes photographs and tables of specifications. 4 pages. International Instruments Inc., 88 Marsh Hill Rd., Orange, Conn.

Circle 625 on Page 19

Centrifugal Pumps

Catalog Section S-7253 describes impervious graphite Type-F centrifugal pumps in four basic sizes providing capacities to 140 gpm and heads to 67 ft. Cut-away drawing clearly illustrates the features of the carbon-to-carbon rotary seal. Pump-characteristic curves based on clear water at 70 F plot total head, brake horsepower, and net positive suction head against gpm for the four sizes. Sketch and table present all dimensions of 20 available models. 4 pages. National Carbon Co., Div., Union Carbide Corp., 270 Park Ave., New York 17, N. Y.

Circle 626 on Page 19

Why Die Stamped Circuits by
Dytronics?

ELECTRICAL PROPERTIES UNIMPAIRED

Die stamped circuits are produced by a dry technique which employs a heated metal-cutting die to delineate the conductor pattern and bond it to the base material by activating the adhesive between the metal foil and the insulating material.

The electrical properties of the base material are unimpaired, because no chemicals are used, and there is no adhesive residue or residual metal on the insulating surfaces. This gives the designer the advantage of selecting base materials for physical and electrical properties without considering chemical resistance.

A new booklet, "Designing with Dytronics Die Stamped Circuits," will help you evaluate and design with die stamped circuits. Write for your free copy today.



Dytronics
INCORPORATED

ROCHESTER 47, MICH.

A subsidiary of Taylor Fibre Co.
Norristown, Pa.

Circle 320 on Page 19

On again
Off again
50 times
over!



**When frequent adjustment or dis-assembly is anticipated
USE NYLON INSERT ELASTIC STOP® NUTS**



Extended re-useability is built into every standard Elastic Stop nut. The tough nylon locking collar does the trick.

It grips entering bolt threads with a plastic-smooth perfect fit that dampens impact loads, absolutely resists vibration, yet never galls or damages bolt threads. The nut may be "stopped" at any place on the bolt, whether seated or not, for precision adjustment. When the nut is wrenched off for routine maintenance, the nylon collar, due to its elastic recovery, tends to resume its original shape. Thus upon re-installation it grips the bolt threads as effectively as on the original installation. And this on-off cycle can be

repeated over 50 times on any bolt of standard quality without loss of holding power.

The nylon locking collar can also be used to seal off liquid seepage along the bolt threads and to prevent moisture from entering the load carrying areas. It is inert to oils, gasolines, salt atmospheres and common acids.

Consider the economy to you and your customers of this kind of fastener performance. Let us prove it to you. Ask for free test samples . . . or a copy of Recommended Test Procedures for Determining Locknut Re-Useability. Write: Elastic Stop Nut Corporation of America, Dept. S50 - 44, Vauxhall Road, Union, New Jersey.



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ELASTIC STOP NUT CORPORATION OF AMERICA

GEAR PROBLEMS?

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FAIRFIELD!

GEAR PERFORMANCE to match the ever-increasing power and speed of modern machines is a Fairfield specialty. This is possible because Fairfield has long held a position of leadership in utilizing the most advanced methods, equipment, and techniques for producing better gears **EFFICIENTLY, ECONOMICALLY**. By keeping apace with modern engineering trends, Fairfield renders an invaluable service to many of the nation's leading machinery builders.

If you have a gear problem, check with Fairfield. Our engineers are well-qualified to give you expert recommendations. **LARGE or SMALL**, your requirements will receive prompt attention. CALL OR WRITE.

SPUR GEARS—Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.

HERRINGBONE—(Fellows Type). Sizes from 1½" to 15"

SPRAL BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

STRAIGHT BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

HYPOID—Sizes from 1½" to 28" dia.

ZEROL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 21" dia.

WORMS AND WORM GEARS—Worms to 7" dia. Worm gears to 36" dia.

SPLINED SHAFTS—Lengths to 72".

DIFFERENTIALS—3,000 to 500,000 inch pounds capacity.

Note: All of the sizes above are approximate.

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illustrated bulletin.



Gears and Differentials



Made to Order for:

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

HELPFUL LITERATURE

Chain Drives

Engineering Catalog PTCB on Whitney Chain power-transmission chain drives provides integrated chain and sprocket engineering and application data based on new horsepower ratings proposed by ARSCM. Featured is a quick-selection chart which simplifies finding recommended chain pitch numbers. Also included is a fold-out, quick-reference guide to the complete line. Pictures, tables, diagrams, and dimensional drawings are incorporated. About 125 pages. Dept. MJ, Foote Bros. Gear & Machine Corp., 4545 S. Western Blvd., Chicago 9, Ill.

Circle 627 on Page 19

Torque-Tension Manual

Design Manual 6101 includes 12 tables listing specific recommended installation torque values for thin and standard-height UNC and UNF hex-type Elastic Stop nuts. It discusses factors to be considered in selecting a tightening torque, and also the effects of the use of lubricants. Additional data include tables of tensile-stress areas and tables of bolt strengths. 18 pages. Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J.

Circle 628 on Page 19

Bolt-Strain Gage

Bulletin 361 describes and pictures Strainsert bolt, consisting of an electric strain gage bonded and sealed in a small hole along the longitudinal neutral axis of the bolt. Functions are explained, and mechanical and electrical specifications are given. Standard installations are described. 4 pages. Strainsert Co., Bridgeport, Pa.

Circle 629 on Page 19

Drafting Aids

Bulletin P-30A is an illustrated table which includes all pre-cut, pressure-sensitive shapes and narrow types required to make paste-up printed-circuit drawings that conform to military specifications. Many new nonmilitary configurations are also included. Bulletin provides illustrated cross-reference between corresponding sizes of donut-type pads, teardrop, and twin pads. Illustrations are actual size to assist in making visual comparisons. 6 pages. By-Buk Co., 4314 W. Pico Blvd., Los Angeles 19, Calif.

Circle 630 on Page 19

Industrial Fasteners

Complete line of standard precision industrial fasteners is discussed in Form 2449. Bulletin provides a review of specification information on Unbrako, Flexloc, Sel-Lok, and Hallowell lines. It gives basic data on types, sizes, threads, and plating, and spells out design features and application information. Specification information on materials, threads, and size ranges is contained in a series of tables, each supplemented by sketches identifying type of fastener. 8 pages. Box 102, Standard Pressed Steel Co., Jenkintown, Pa.

Circle 631 on Page 19

**Because we've always
welcomed "little" jobs, too—**

**We've become
the biggest in the
investment
casting field...**



No investment casting job has ever been or ever will be too small for us.

WE DON'T HAVE ANY "SIDELINES," nor is investment casting only a sideline with us. It is the "be-all and end-all" of our economic existence.

AS A RESULT: anybody who thinks that an investment casting will help him solve a problem gets the unqualified, attention of the top talent we have to offer—from our trained field engineers, our design engineers, our estimating staff, our tooling men, and our production specialists. No one of these groups cares whether your order is for 50 parts or 100,000. If they accept the order, they want it handled to or above "specs".

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ARWOOD IS READY WHEN THEY DO . . . more so than any other investment caster. In fact, we can

take in stride all the volume that's required. Our five plants, each fully integrated can handle the biggest job you can offer.

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HELPFUL LITERATURE



At a cost comparable to an ordinary restrictor or needle valve, you can have pressure-compensated flow control in your hydraulic circuits.

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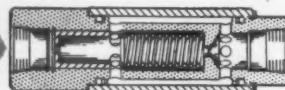
Wide range of sizes available— $\frac{1}{4}$ " to 1 $\frac{1}{2}$ " N.P.T.F. and $\frac{1}{4}$ " to 1" S.A.E. tube.

Flows to 100 g.p.m. can be controlled.

Factory-calibrated and tested to $\pm 10\%$ tolerance. Closer tolerances available.

Require little more space than pipe or tube in which installed.

Trouble-free in operation—tens of thousands in use.



Unit senses pressure drop across precise orifice and reacts to control flow with desired limits.

Send today for new Catalog 1002.



W-8108



725 Custer Ave., Evanston, Ill.
Circle 324 on Page 19

Liquid-Level Controls

Line of electronic floatless liquid-level controls is described in Bulletin 334. Included are complete details on two types designed for use on high-resistance liquids to 12.5 megohms, low-resistance liquids where low electrode potential is desired, and long-distance applications requiring positive control from remote locations. Tables and diagrams are included. 4 pages. B/W Controller Corp., 2200 E. Maple Rd., Birmingham, Mich.

Circle 632 on Page 19

Welded Steel Designing

"Studies in Applied Weldesign" 1204.3 provides information on how to improve rigidity and save weight in thin, flat structures by designing in welded steel. Discussion concerns design of machine-tool tables, vacuum chucks, flat tables with keyways, and loading ramps. Many photographs and drawings illustrate text material. 4 pages. Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio.

Circle 633 on Page 19

Miniature Bearings

Illustrated Catalog 3E covers radial Filmoseal, radial Ultra-Light, radial Conrad, radial flanged, pivot, miniature roller, and special bearings in RMB line. Along with full dimensional data and drawings, actual size drawings are presented. Photographs are shown of the devices in which the bearings are used, and cross-section sketch shows how the bearing is installed. 16 pages. Landis & Gyr Inc., 45 W. 45th St., New York 36, N.Y.

Circle 634 on Page 19

Timing Screws

Illustrated Brochure STE-596 describes Kinsley custom-engineered timing screws. Line drawings and photographs show engineering principles of the units. Design considerations, specifications, and ordering information are also given. 4 pages. Arthur Colton Co., 3400 E. Lafayette, Detroit 7, Mich.

Circle 635 on Page 19

Nylon Stock Shapes

New MC Nylon is described in Bulletin MC-2. Physical property data and suggested applications are presented. Complete mill shape availabilities are listed, including large size of rod, tubular bar, and plate formerly unavailable in other formulations. 4 pages. Polymer Corp., 2120 Fairmont Ave., Reading, Pa.

Circle 636 on Page 19

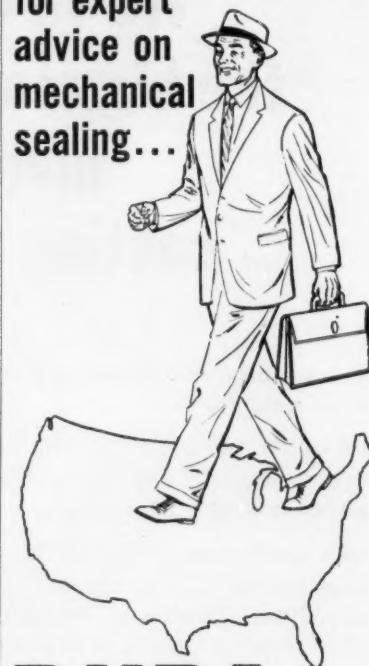
Power-Transmission Equipment

Catalog GC-101-F illustrates and describes complete line of power-transmission equipment. Catalog contains a description and listing of such stock parts as belts, sheaves, sprockets, pulleys, couplings, and hubs. Photographs and tables provide all pertinent data. 24 pages. Browning Mfg. Co., Maysville, Ky.

Circle 637 on Page 19

Call in a DURA MAN

for expert advice on mechanical sealing...



DURA SEAL

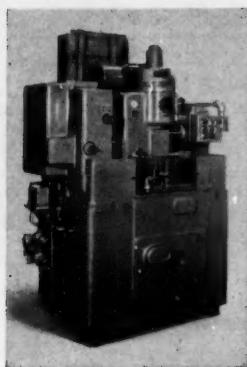
Sales and Service is Nation-wide

Mechanical sealing service at its best! Fifty-six trained men working out of thirty area offices offer assistance in meeting your sealing needs.



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Circle 325 on Page 19



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*in mind!**



It's practical and economical to produce odd-shaped parts on a Fellows Gear Shaper.

Merely by using special cutters and fixtures on *standard* Fellows machines, an almost limitless variety of internal and external contours can be generated. In many cases, a single set-up does what ordinarily would require several conventional shop operations.

And, of course, *standard* Fellows generating equipment also provides high production of internal and external spur and helical gears, from "miniatures" up to 120 inches OD.

This versatile production method is fully described and illustrated in "The Art of Generating with a Reciprocating Tool." Send for your free copy of this informative booklet.

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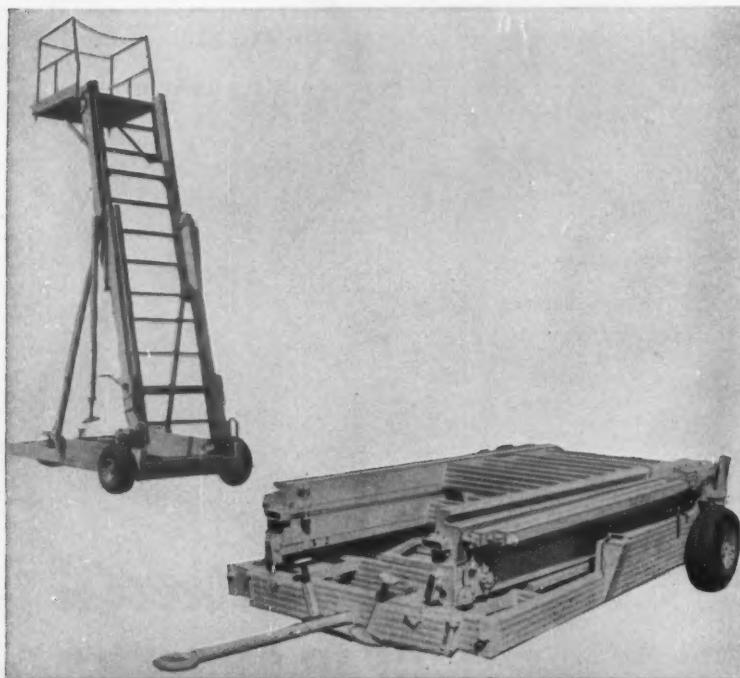
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THE
PRECISION
LINE

Fellows Gear Production Equipment

LUBRICATION REPORT

(TFE coating)



Application: Portable Aircraft Maintenance Stand Lubrication.

Problem: To minimize sliding friction at widely varying temperatures.

Solution: 'EMRALON'® 310 (a tetrafluoroethylene pigmented, bonded film lubricant) spray-applied and baked at 300°F. for one hour.

RESULT: ALL-WEATHER COATING GIVES TELESCOPING STAND NEEDED LOW-FRICTION SLIDING SURFACES

This lightweight portable aircraft maintenance stand was developed for use by the U. S. military forces by South River Metal Products Co., Inc., of South River, N. J. Approximately 40 lineal feet of telescoping surfaces are contained in the stand which elevates to 13 feet for use, and compacts to a height of only 2 feet for transporting. Tests showed that the sliding magnesium sections were readily subject to galling and seizure. The dry-film coating obtained with Acheson's 'EMRALON' 310 provides the necessary lubrication through an ambient range from desert heat to Arctic sub-zero temperatures . . . and does not cake, evaporate or freeze.

Perhaps one of Acheson's series of TFE coatings can help solve your dry-film lubricating problem. Write for 'EMRALON' 310 or 'EMRALON' 320 (air dry) Product Data Sheets. Dept. MD-41.

ACHESON - First name in solid lubricants for fifty-three years.



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A division of Acheson Industries, Inc.

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HELPFUL LITERATURE

Turbine Flowmeters

Two new models of the turbine flowmeter are described in Specification Bulletin 10C1505. Materials of construction, performance characteristics, dimensional drawings, and capacities are given. Six transistorized totalizers and batch controllers designed for use with the turbine meters are fully described and illustrated in auxiliary Bulletin 51-2860. 14 pages total. Fischer & Porter Co., 852 Jacksonville Rd., Warminster, Pa.

Circle 638 on Page 19

Torque Measurements

New brochure illustrates how to measure the torque characteristics and speed of motors, gear trains, servo mechanisms, and potentiometers. It covers torque ranges from $\frac{1}{4}$ gm-cm to 200 lb-in. Booklet includes formulas for computing power and efficiency, and methods of using stroboscopes and tachometers for analyzing rotating motion. 12 pages. Power Instruments Inc., 7352 N. Lawndale Ave., Skokie, Ill.

Circle 639 on Page 19

Hose Assemblies

Reference Bulletin IEB-53 provides a quick guide to company's hose assembly numbers. It covers the various categories of end fittings used for low, medium, and high-pressure hose assemblies, in addition to assemblies of Teflon with Super Gem fittings. Bulletin also provides hose types to be used with each type of fitting. 4 pages. Aeroquip Corp., Jackson, Mich.

Circle 640 on Page 19

Self-Locking Cap Screw

New bulletin describes self-locking Kapscrew, its design and principle of locking. Pictures and large drawing provide data on the screw, which withstands temperatures to 1600°F and is reusable. 4 pages. Klincher Kapscrew Inc., Dept. KKL-262, 2153 Hillside Ave., Indianapolis 18, Ind.

Circle 641 on Page 19

Pump-Motor

Close-coupled pump-motor Bulletin 1455 covers both polyphase and single-phase motors. Discussion is devoted to mechanical variations which make close-coupled pump-motors. Standard keyed shafts, as well as usual extended shafts, are covered. 4 pages. Century Electric Co., 18th & Pine Streets, St. Louis 3, Mo.

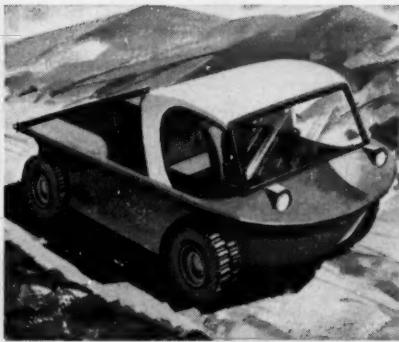
Circle 642 on Page 19

Sight-Flow Indicators

Bulletin 18W completely describes line of sight-flow indicators. Construction details, dimensions, and operating limits are given for flapper and rotary types, with threaded and flanged connections. New Flo-Eye indicator is also included. 4 pages. Dept. M-W, Schutte & Koerting Co., Cornwells Heights, Bucks County, Pa.

Circle 643 on Page 19

A MOLDING COMPOUND WITH 65,000 PSI FLEXURAL STRENGTH!



The "Fox" swimming test rig is presently under development by Ordnance Tank-Automotive Command.

"SCOTCHPLY" Reinforced Molding Compound Type 1100 opens up new possibilities in critical design areas. This new epoxy-fiberglass compound combines outstanding uniformity and high strength far in excess of other molding compounds.

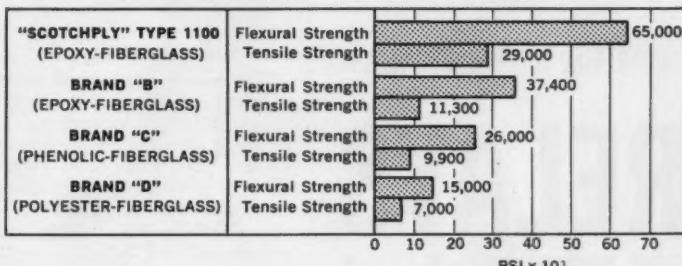
This is why Design Engineers at Detroit Arsenal selected "SCOTCHPLY" Type 1100 as a test material for their swimming test rig wheels. This application demands a lightweight, corrosion resistant material to meet stringent strength and durability tests. For example: Bureau of Standards rim test requires 100,000 revolutions for a steel rim; "SCOTCHPLY" Type 1100 rims exceeded this requirement by 4,350,000 revolutions.

The outstanding performance of Type 1100 is due primarily to an exclusive 3M manufacturing process which produces a uniformity of coating previously not obtainable. This results in a uniform flow in the molding process and a precise uniformity of glass-resin distribution in the finished part.

For information on "SCOTCHPLY" Molding Compound Type 1100, write: Reinforced Plastic Division, 3M Co., Dept. XAD-41, 900 Bush Ave., St. Paul 6, Minn.

Comparison graph shows that the flexural and tensile strengths of "SCOTCHPLY" Molding Compound Type 1100 top other reinforced molding compounds.

MOLDING COMPOUND COMPARISON GRAPH
(ROOM TEMPERATURE PROPERTIES - 1/2" GLASS FIBERS)



TEST WHEEL FOR THE "FOX" SWIMMING TEST RIG IS MOLDED FROM "SCOTCHPLY" TYPE 1100 MOLDING COMPOUND.

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Open Type Relay. Up to 3PDT, 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 10.



GENERAL PURPOSE
Plug-In Type Relay. Contact arrangements up to 3PDT. 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 10.



PRINTED CIRCUIT Open Type Relay. Up to 3PDT. 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 11.



211 River Street, Orange, N. J.
Industrial Relays, Foot Switches, Buzzers, Coils
Phone: ORange 2-8200

Circle 329 on Page 19

HELPFUL LITERATURE

Rulon, Teflon Parts

Brochure 9572 compares electrical, physical, mechanical, and chemical properties of Rulon and Teflon. Illustrated are numerous Rulon parts made for lube-free bearings, O-rings, wear strips, valve seats, thrust washers. Engineering design services for developing special shapes and forms of Rulon and Teflon are discussed. 4 pages. Plastics Div., Dixon Corp., Bristol, R. I.

Circle 644 on Page 19

Silicon Mesa Transistors

Eight new silicon mesa transistors for medium-power audio to medium-frequency applications are described in Bulletins ECG-538 and ECG-528. Many curves in each bulletin point out all important features. Dimensional drawing is also incorporated. 6 pages each bulletin. Semiconductor Products Dept., General Electric Co., Kelley Bldg., Liverpool, N. Y.

Circle 645 on Page 19

Size 8 Components

New booklet pictures and describes line of Size 8 components for aircraft or missile servo-system applications. Synchros, resolvers, servo motors, servo-motor tachometers, gear heads, brake clutches, synchronous motors, and permanent magnetic alternators are included. Each unit is shown with a line drawing, and tables provide pertinent data. 12 pages. Kearfott Div., General Precision Inc., Little Falls, N. J.

Circle 646 on Page 19

Expanded-Foam Plastic

Technical Data Catalog 3 describes Pac-Trim, a reusable, expanded-foam plastic used for packaging, cushioning, and protection of delicate or sensitive equipment. Bulletin includes data on physical, mechanical, and electrical properties. 12 pages. Pac-Tron Inc., Willow Street, Mystic, Conn.

Circle 647 on Page 19

Wood Properties

Chart titled "Why Not Use Wood?" lists properties of 23 domestic woods. Properties include weight in pounds per cubic foot, hardness, strength, splitting qualities, dimensional stability, and resistance to decay. Some comments on uses are included also for each variety of wood. Chart is printed on heavy cardboard. Write on company letterhead to American Wood Working Co., Box 335, Montello, Wis.

Precision Potentiometers

Technical catalog on complete line of precision potentiometers provides detailed specifications, outline drawings, and general information on a wide range of miniature and full-size units from $\frac{1}{4}$ to 5-in. diam. Pictures of all units are included. 28 pages. Write on company letterhead to Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

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UNIFORM TUBES,
INC. COLLEGEVILLE 2, PA.

HUXLEY 9-7276 TWX-CGVL 1044

Circle 330 on Page 19



1001 ACCESSORIES TO INSURE HIGHEST AIR CIRCUITRY PERFORMANCE

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QUALITY AIR CONTROL PRODUCTS

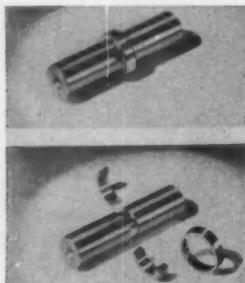
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Shaft Collar

withstands high thrust loads

Conical-shaped split inner ring and locking retainer ring are combined in the Taper-Lock shaft collar. It withstands high thrust loads in one or both directions and provides accurate location for shaft-mounted parts. Split inner ring locks into the shaft, eliminating turned shoulders. Quick, simple assembly is completed by the tapered fit of inner ring and retainer. In addi-



tion to conventional shaft-collar applications, unit can be used to connect air or hydraulic cylinder shafts to other members in high-thrust applications. Collars are available in all sizes to 4 in. diam, external or internal types. Bearing Accessories Co., 7320 Lake Shore Blvd., Mentor, Ohio.

Circle 648 on Page 19

Photoconductive Cell

measures "tungsten light" or daylight accurately

No. 5-I photoconductive cell utilizes a formulation whose sensitivity variation with the color temperature of light approximates closely that of the human eye. Cell conductance measures light (as sensed by the human eye) accurately, whether tungsten or daylight, at color temperatures from 2700 to



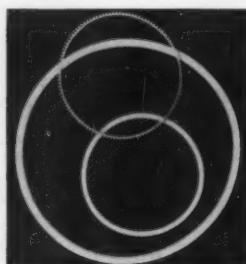
6500 K. A foot-candle meter which incorporates this cell requires no correction filter. Clairex Corp., 19 W. 26th St., New York 10, N. Y.

Circle 649 on Page 19

Teflon Pressure Seals

incorporate stainless-steel spring insert

Line of spring-loaded Teflon pressure seals is available for cryogenic, fuel, oil, gas, and chemical applications. Standard flange seals feature a serrated stainless-steel spring insert (shown) which acts as a compensating pressure on the Teflon seal in temperatures from -420 to +500 F. Insert provides initial sealing at zero pressures, and sealing force increases as pressure increases. Spring also compensates for dimensional changes resulting from tolerance variations, thermal expansion, or contraction and cold flow of the plastic. Seal is flexible and adjusts to out-of-round or warped flanges. It is also reusable after disassembly of a flange joint, is not affected by aging, and can be



used on any flange, including ASA types. Raco Engineering Co., 1650 21st St., Santa Monica, Calif.

Circle 650 on Page 19

Magnetic Reed Switch

has over-all length, including leads, of 1 1/2 in.

Number MRG-1 is a subminiature dry-reed switch with gold-plated contacts, hermetically sealed in an inert atmosphere. Glass body is 1/8 in. diam by 3/4 in. long, and over-all length of switch, including 0.022-in. diam leads, is 1 1/2 in. Switch is rated at 12 v amp maximum, resistive to 1/2 amp, up to 250 v ac. Switch arrangements can be normally open, normally closed with bias magnet, or with a



latching arrangement. Hamlin Inc., Lake & Grove Streets, Lake Mills, Wis.

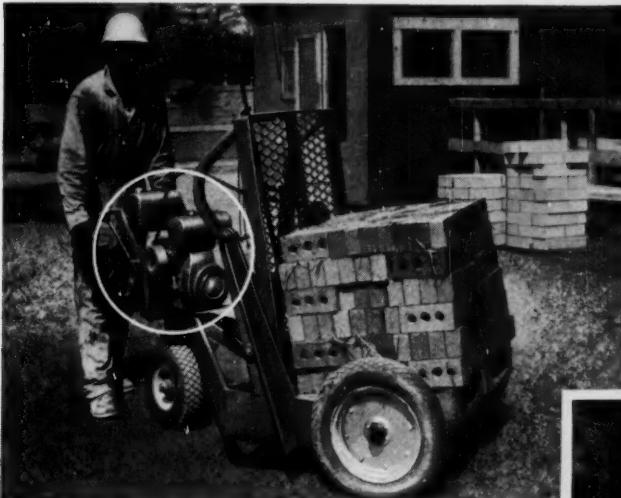
Circle 651 on Page 19

Packaged Journal Bearing

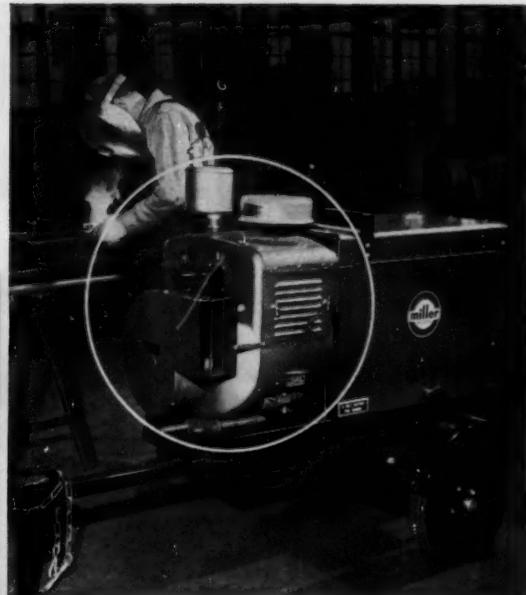
for use in rotating-shaft applications

Permawick bronze bearing is a packaged journal bearing with life-time lubrication. It is interchangeable with general-purpose ball bearings in rotating-shaft applications. Bearing runs quietly and resists humid or abrasive environments. Sintered-bronze bearing assembly is designed for light to moderate loads at moderate speeds, and

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 closures ... 3 Sizes - 500, 750,
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- UP TO 88% LESS INERTIA (W_K²) ...
- UP TO 35% LESS WEIGHT ...
- UP TO 40% LOWER INSTALLED COST ... than cumbersome, hard to enclose "Flywheel-type" brakes of similar torque and thermal capacity!

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Request Stearns New Product Preview 2-61-8



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NEW PARTS AND MATERIALS



TANN PERMAWICK® BRONZE BEARING

has a derated PV value of 25,000. Bearing operates in -25 to +200 F temperatures. Thirteen standard sizes range from $\frac{1}{4}$ in. ID x $\frac{3}{4}$ in. OD to 20 mm ID x 47 mm OD. Tann Bearing Co., Div., Tann Corp., 3750 E. Outer Drive, Detroit 34, Mich.

Circle 652 on Page 19

Two-Part Epoxy Adhesive

provides tensile shear
 strengths over 2000 psi

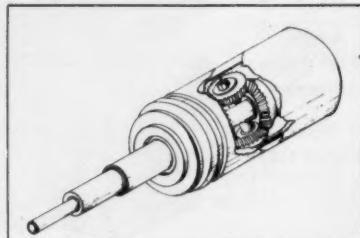
Adhesive X-305 is a rapid-bonding, two-part liquid epoxy adhesive suitable for use at room temperature. Setting in 45 sec, it immediately provides tensile shear strengths of over 2000 psi. Features include nonflammability, low exotherm, lack of fuming on setting, and easy-to-use, noncritical mixing ratio. Adhesive is recommended in applications requiring quick-setting adhesives such as repairs to printed circuits, fastening and sealing of electronic components, and laminating. It is available at present in limited quantities. Mereco Products Div., Metachem Resins Corp., 530 Wellington Ave., Cranston, R. I.

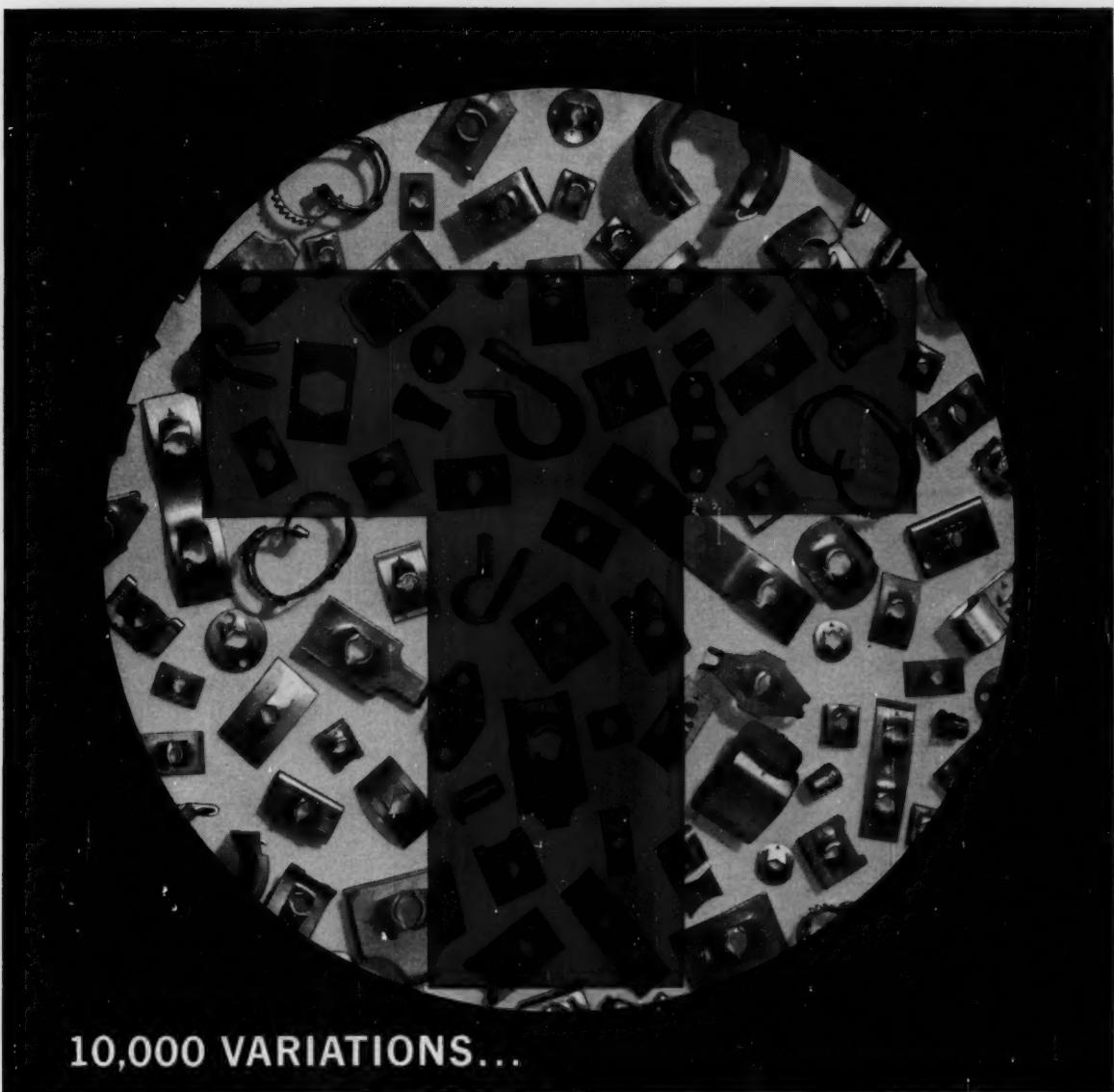
Circle 653 on Page 19

Enclosed Differential

in BuOrd sizes
 5, 8, 11, 15, and 18

No. T753 single-end enclosed differential provides high-speed rota-





10,000 VARIATIONS...

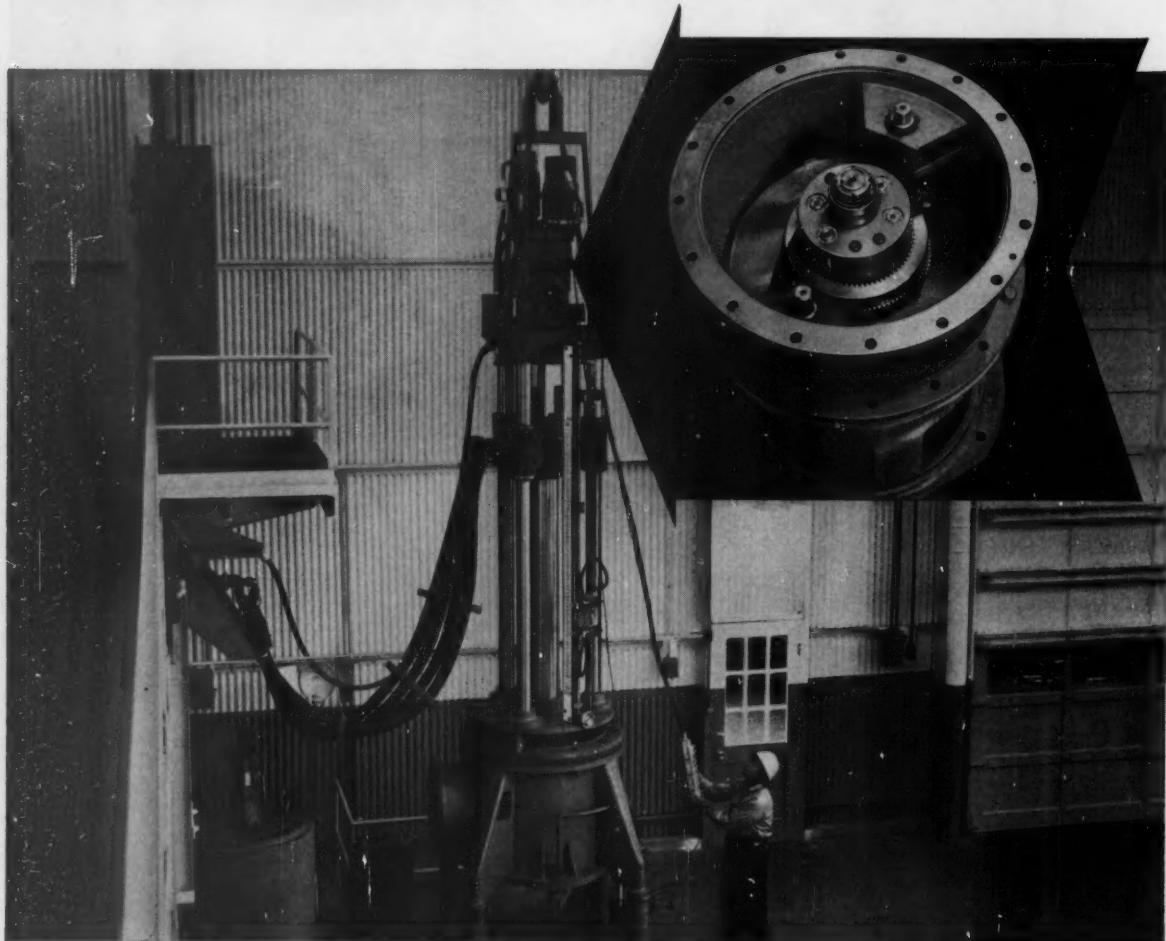
all stamped with the **T-MARK** of total reliability

Other spring fasteners may *look* like Tinnerman SPEED NUTS. But only those stamped with the T-mark really *are* SPEED NUTS, made to Tinnerman's high, precise standards of reliability. Tinnerman quality controls are the most stringent in the industry. And only Tinnerman stocks a *half-billion* SPEED NUTS . . . is tooled to turn out 10,000 variations . . . develops 25 *new* designs each week. Protect your product's good name by insisting on genuine SPEED NUTS. Stamped with the Tinnerman "T"—the mark of total reliability. *Tinnerman Products, Inc., Department 12, Box 6688, Cleveland 1, Ohio.*

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario.
GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales.
FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine).
GERMANY: Mecano Simmonds GMBH, Heidelberg.



Philadelphia Precision Ground Gearing Increases Sensitivity of New Vacuum Arc Furnace



Philadelphia precision ground gearing is responsible for smoother, more efficient operation of a new consumable electrode vacuum arc melting furnace installed at Standard Steel Works Division of Baldwin-Lima-Hamilton Corporation.

This specially designed differential reduction, planetary gear drive greatly increased the efficiency of the furnace. The old problem of stop-start action with uneven electrode burnoff has been completely eliminated. Now, uniform electrode feed permits arc voltage to be maintained within $\pm .1$ Volt. Electrode burnoff is uniform.

This drive problem is typical of hundreds that have been solved with Philadelphia hardened, precision

ground gearing . . . problems where improved gear accuracies have resulted in space and weight savings, higher-speed operation, reduced sound and vibration levels, and longer gear life—all at no increase in cost.

Our experienced engineering staff, specialists in all types of power transmission problems, make sure that proper design and materials combine to meet your most exacting needs.



For more complete information,
write on your company letterhead
for our Catalog: AN ADVANCED
CONCEPT IN MODERN GEARS.

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

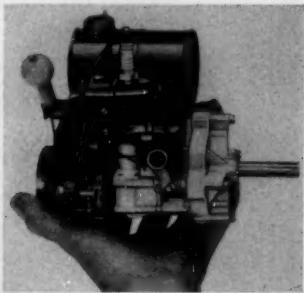
tion, minimum backlash, low breakaway torque, and maximum rotational torque output. It is available in BuOrd sizes 5, 8, 11, 15, and 18. Differential has precision ball bearings throughout; construction is stainless steel and aluminum. Component Div., Sterling Precision Corp., 5 Sintsink Drive, Port Washington, L. I., N. Y.

Circle 654 on Page 19

Compact Engines

now incorporate reduction gears

Compact engines with reduction gears have take-off shaft speeds of 6300, 3300, 1700 and 900 rpm. Size of the engines is $5\frac{1}{4}$ in. high, and weight, with fuel tank, is $3\frac{3}{4}$ lb; with tank and reduction gears,



total weight is $4\frac{1}{4}$ lb. Units are available for use in compact, portable, gasoline-powered tools. Torque available in the 6300-rpm engine is 7 lb-in. In the 3300-rpm engine, it is 14 lb-in., in the 1700-rpm engine, 27 lb-in., and in the 900 rpm-unit, it is 51 lb-in. All gear boxes are closed and gears run in oil; diaphragm carburetors provide all-altitude operation. Ohlsson & Rice, 3340 Emery St., Los Angeles 23, Calif.

Circle 655 on Page 19

Miniature Cam Followers

have face widths of 0.1406 to 0.1960 in.

Miniature stainless-steel precision cam followers have ODs of $\frac{1}{4}$ to $\frac{5}{8}$ in. Available in face widths from 0.1406 to 0.1960 in., units incorporate a shielded ABEC 7 tolerance ball bearing fitted on a concentric ground shaft. Units are (Please turn to Page 226)



THE SPARE PARTS PROBLEM

The Electronics Business may not be the most tranquil enterprise for anyone to get into — either as a buyer or seller — as evidenced by one of the problems currently plaguing both component makers and their customers. In a nutshell, the trouble is "equivalent" parts, made by a low bidder, failing to behave as the originals did. The explanation, while not as simple as this, seems to boil down to the fact that specs and descriptive data alone aren't enough for anyone to duplicate the performance of somebody else's original part. It could be a matter of the inability of the blueprint and the mimeograph machine to be a satisfactory substitute for the original manufacturer's experience, engineering skill, assembly methods and quality control.

No one can argue the merits of saving money, and a good part at the lowest possible cost is a commendable achievement. But when "low quote" means failure of critical equipment and personal hazard,

there's not much to be said for economy. On the other hand, if the low man does get all the information he needs to build an exact replacement of the original part (assuming he can build it), he is automatically getting the benefit of a great deal of work done and paid for by the original manufacturer. The polite term is usually "proprietary data." Understandably, this arouses the "unfair competition" ogre.

We don't like to give away proprietary information any more than the next person. Neither do we like to see unreliable components endangering life and limb. We think part of the answer* may be to give the second man the same problem you gave the original supplier—not the blueprinted solution to imitate. Then test his result as carefully as you did the original successful one. This way, the odds are strongly in favor of your getting something that will work — and perhaps work even better.

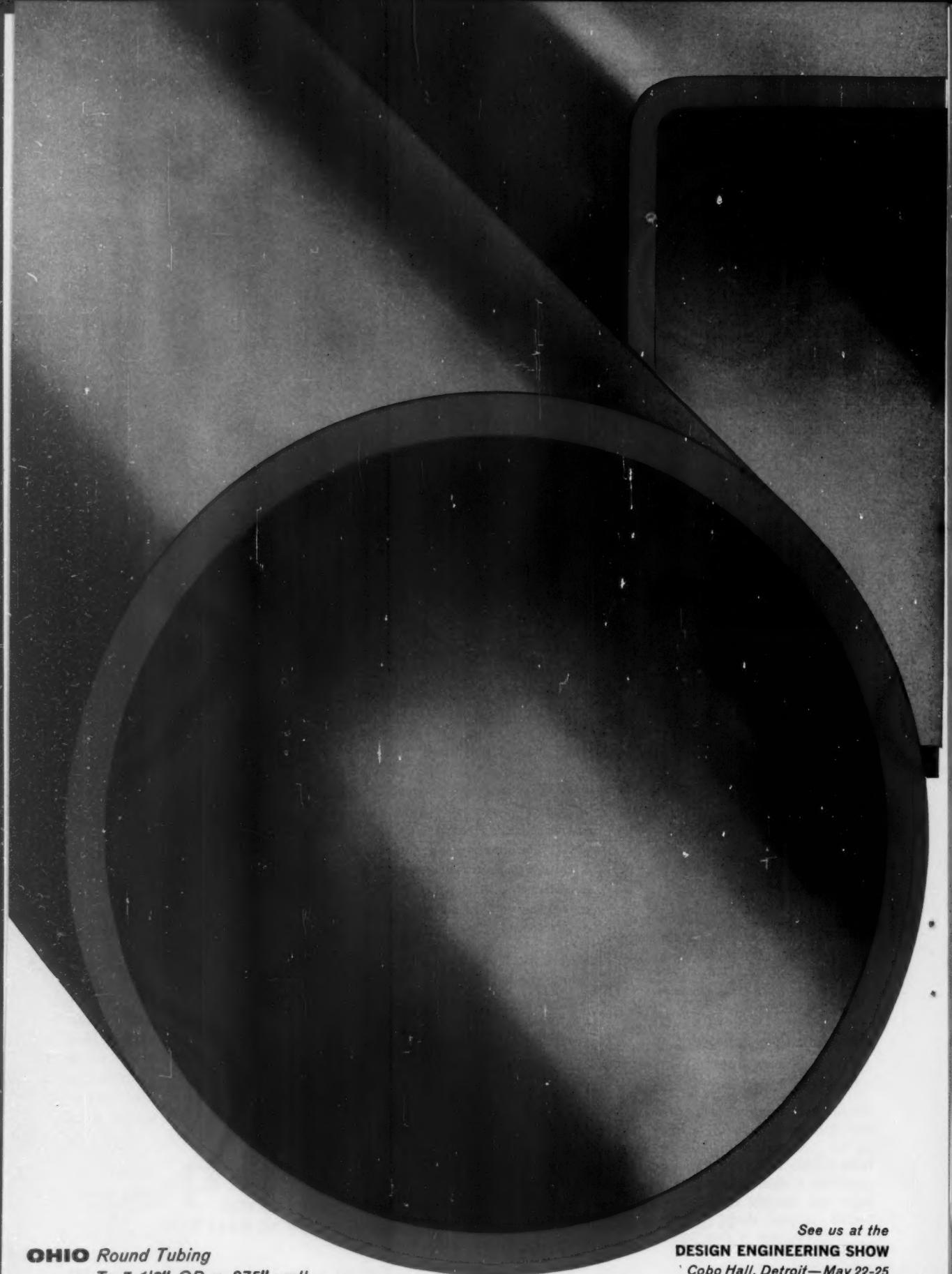
What do you think the answer is?

* E. W. Schrader, Western Editor of DESIGN NEWS, made some good observations on this whole subject; see pp. 6-7, Jan. 16 issue.

SIGMA

SIGMA INSTRUMENTS, INC.

89 Pearl St., So. Braintree 85, Mass.



OHIO Round Tubing
To 7-1/2" OD x .375" wall

See us at the
DESIGN ENGINEERING SHOW
Cobo Hall, Detroit—May 22-25

A-3573A



OHIO Square Tubing
To 6" x 6" x .259" wall

OHIO Rectangular Tubing
To 7-1/2" major diameter x .259" wall
Typical 4" x 6" x .259" wall section illustrated

Announcing Mechanical — Pressure — Cold Drawn **OHIO QUALITY WELDED STEEL TUBING** *in larger sizes...heavier wall thicknesses*

New sizes and heavier wall thicknesses of Ohio Quality Welded Steel Tubing (up to 7½" OD) now parallel the sizes of famous Ohio Seamless Steel Tubing. That means — now more than ever — there's a type and size of Ohio tube to fit your special requirements exactly. And since we make both types, we're in a position to recommend the best type for your own particular needs. Ohio Tubing — either welded or seamless — is just "made to order" for your product.

Circle 337 on Page 19



OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Cut along line and send air mail to save time.



RUSH me, without obligation, latest information on new larger sizes and heavier wall thicknesses of Ohio Welded Steel Tubing.

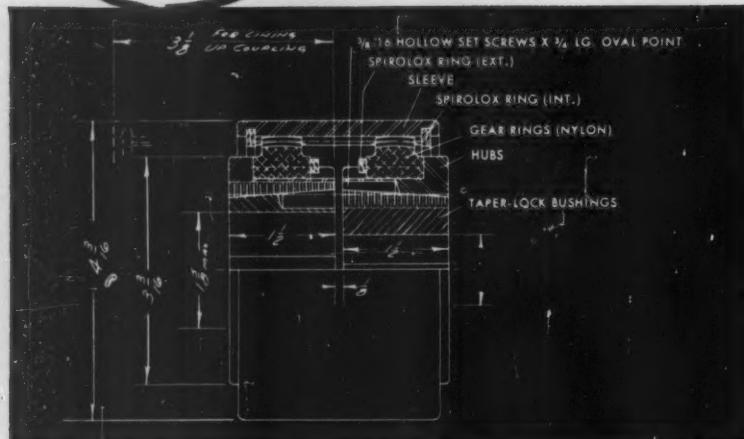
Name _____ Title _____

Company _____

Address _____ City _____ State _____

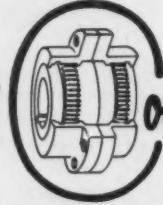
design facts...on

WALDRON Series "M" Couplings



The new Series M couplings—with nylon gears and steel sleeves—need no lubrication. Equipped with Taper-Lock bushings—each coupling size can accommodate a range of shaft sizes. For instance, the 162M, now available, will take shafts from $1\frac{1}{2}$ " to $1\frac{1}{8}$ " with proper size Taper-Lock bushings, and up to 2" without the bushings. Hubs are machined from bar stock and the one piece sleeve is made of steel. This design means a smaller, light weight coupling that is easier to install and maintain and yet can transmit the necessary power. Size 162, Series M gear couplings can be used for continuous operation up to 5000 rpm at torques up to approximately 2000 inch pounds.

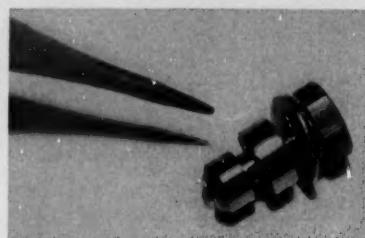
WRITE FOR CATALOG

WALDRON  couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.

NEW PARTS AND MATERIALS

(Continued from Page 223)



furnished complete with spacers, lock washer, and hex nut. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 656 on Page 19

Alkaline Batteries

have long storage life
and leakproof design

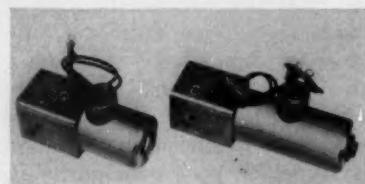
Multipurpose alkaline batteries are available for portable radios, photo-flash service, and flashlights. Performance and price of the batteries lie between those of the conventional zinc-carbon type and the mercury-type batteries. Batteries provide long useful life, long storage life, and leakproof design. Alkaline battery does not require a rest period, operates with the same efficiency in continuous or intermittent service. Types include: VS1334, a 1.5-v penlight cell; VS1335, a 1.5-v C-cell; VS1073, a 1.5-v N-cell; and VS1149, a 4.5-v battery specifically designed for portable radios. Electron Tube Div., Radio Corp. of America, 30 Rockefeller Plaza, New York 20, N. Y.

Circle 657 on Page 19

Miniature Directional Valves

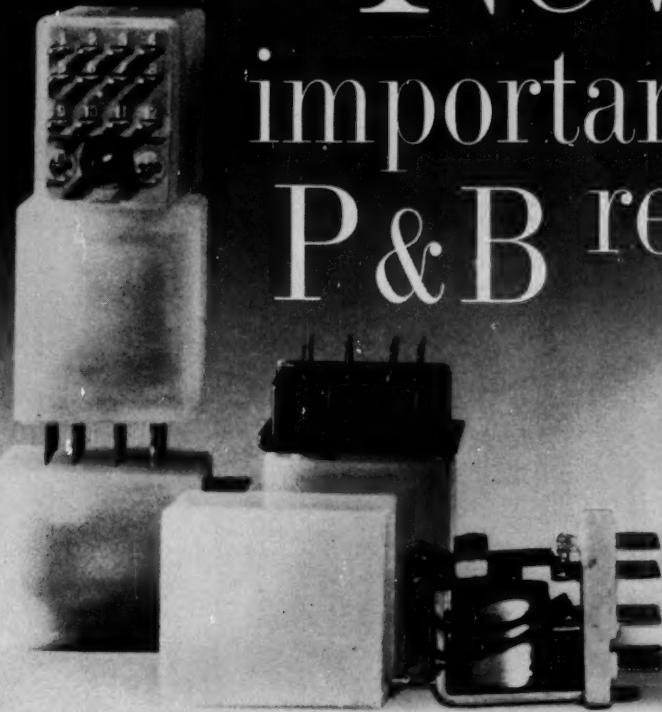
for oil-hydraulic systems
operate to 1000 psi

Series DIL gasket-mounted miniature directional valves are available for use in small-volume oil-hydraulic systems. They are suitable for operation to 1000 psi and have a maximum capacity of 2 gpm.



Circle 339 on Page 19→

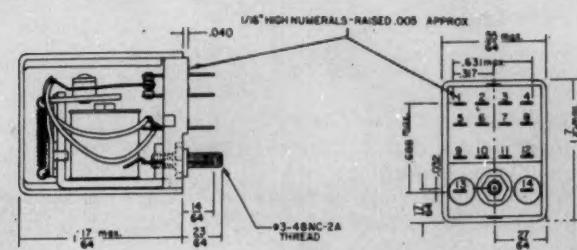
a New and important P&B relay . . .



having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES RELAY NOW AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

KHP SERIES SPECIFICATIONS

CONTACTS:

Arrangement: 4 Form C, 2 Form Z.

Material: $\frac{3}{16}$ " dia. Silver standard. Silver cadmium oxide and gold alloy available.

Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:

Resistance: 11,000 ohms max.

Temperature: Operating Ambient: -45°C . to $+70^{\circ}\text{C}$.

Power: 0.5 watts min. operate @ 25°C . 0.9 watts nom. @ 25°C . 2.0 watts max. @ 25°C .

TIMING VALUES:

Nominal Voltage @ 25°C .

Max. Values

Full-on time

15 ms

Drop-out time

5 ms

INSULATION RESISTANCE:

1500 megohms min.

DIELECTRIC STRENGTH:

500 Volts RMS 60 cycles between contacts.

1000 Volts RMS 60 cycles between other elements.

MECH. LIFE:

In excess of 100 million cycles.

SOCKET:

Solder lug or printed circuit terminals.

Available as accessory.

DUST COVER:

Standard.

TERMINALS:

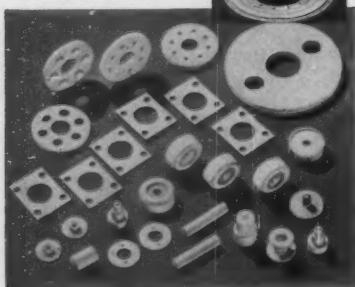
Solder lug and taper tab.

Fabrication...

THE MOST
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STEP IN
*TEFLON



*Du Pont Trademark



For instance, Crane Packing Company's new Teflon products plant was especially designed to obtain the highest quality fabrication of this material and includes the very latest in extruding, molding, curing and machining equipment. Result: *parts and components that retain all of Teflon's outstanding electrical, mechanical, anti-corrosive, heat-resistant and other properties.*

Whether you get this quality depends on your selection of a fabricator. Why not choose the best?

Contact us about
your requirements.
Request Bulletin T-110.



CRANE PACKING COMPANY

6425 Oakton Street, Morton Grove, Illinois
(Chicago Suburb)

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.
Circle 340 on Page 19

NEW PARTS AND MATERIALS

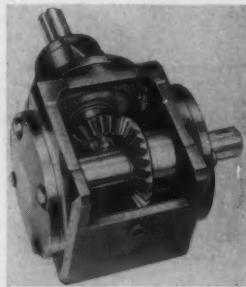
Simple, ac and dc solenoids, with low current consumption, are available in all standard voltages. Valves are offered as four-way units in both single and double-solenoid models. Vickers Inc., Div., Sperry Rand Corp., Detroit 32, Mich.

Circle 658 on Page 19

Gear Box

transmits up to 45 hp

Model 90 gear box is available in a variety of ratios and choice of shaft rotations. It features easy disassembly for simple gear-lash adjustment. Steel-cut gears on ground steel shafts turn on Timken



roller bearings and transmit up to 45 hp. Input rotation is either clockwise or counterclockwise. Unit is available in 1:1, 1.5:1 and 2:1 ratios, or reverse ratios. On 1:1 units, forged or hardened forged gears can be used. Shafts can be pinned, keyed, or splined. Length can be supplied to fit a particular application. Maximum standard shaft size is 1 1/4 in. Von Ruden Mfg. Co., Claremont, Minn.

Circle 659 on Page 19

Rotary Face Seal

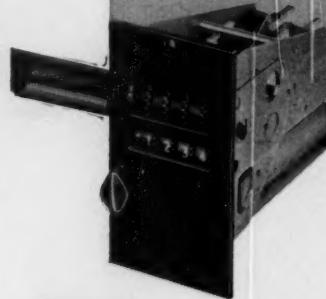
for corrosive fuels and
other fluids

Small, beryllium-copper rotary face seal is for use in jet fuel and oronite systems of high-performance aircraft, or in other applications where high pressures and extended temperature ranges occur. It is particularly applicable where corrosive fluids are used. Seal consists of a retaining housing which holds a machined bellows, faced with carbon, Teflon, or similar materials suited to specific needs. Seal is en-

Take advantage of these
features:

- Size
- Speed
- Capacity
- Cost

and
accuracy



SPECIFY

SODECO
SMALL PANEL-MOUNTED
PREDETERMINING
IMPULSE COUNTERS

Size: only 1 1/4" x 3 1/4"
Speed: up to 10 & 25 imp/sec.
Capacity: 9,999 counts
Cost: Surprisingly low
Accuracy: 100%
Easy to set
Available with remote electric
or manual reset.

This precision instrument has
the 100% accuracy feature
typical of digital equipment.
The in-line presentation, rather
than dials, makes for substantially
easier digital readouts. It
is truly a sophisticated control
in a compact package. Power
requirement is low. And, you'll
also be amazed at the low price.

Write for complete technical data

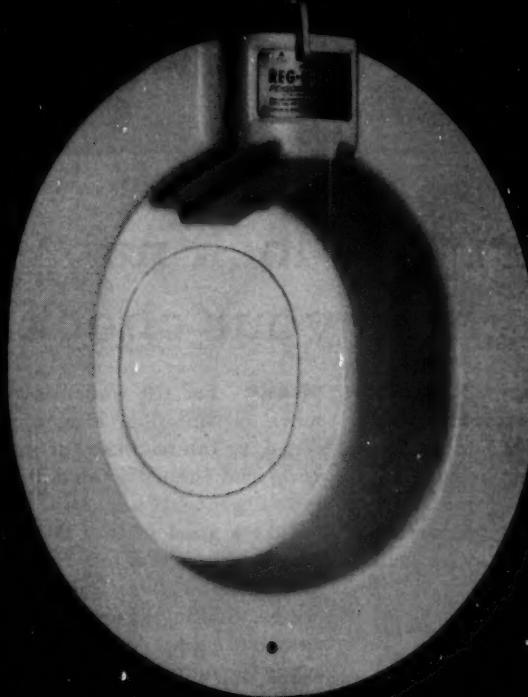
LANDIS & GYR, INC.
45 West 45th Street • New York 36, N.Y.

Circle 341 on Page 19

there are always
good reasons for
designing it in

AVISUN

polypropylene



Vacuum formed—another AviSun first! The Reg-U-Temp Personal Sitz Bath (patented), manufactured by Harlan M. Buck, Inc., is the first commercial application of vacuum formed polypropylene. Vacuum formed by Speck Plastics from CAMPCO sheet.

in this Sitz Bath
it's toughness!

Only polypropylene has the stamina to meet this tough hospital requirement. It can be autoclaved at 250° F. Shrugs off soap solutions, cleaning compounds or alcohol. Light-weight, yet resists rough handling or dropping. Smooth, easy-to-clean surface—warm and pleasant to the touch. Low cost—makes "personal" sitz bath possible—multiplies hospital sitz bath facilities.

Polypropylene makes better products at lower cost. No other material has this combination of properties:

1. Heat Resistance
2. Toughness
3. Chemical Resistance
4. Economy

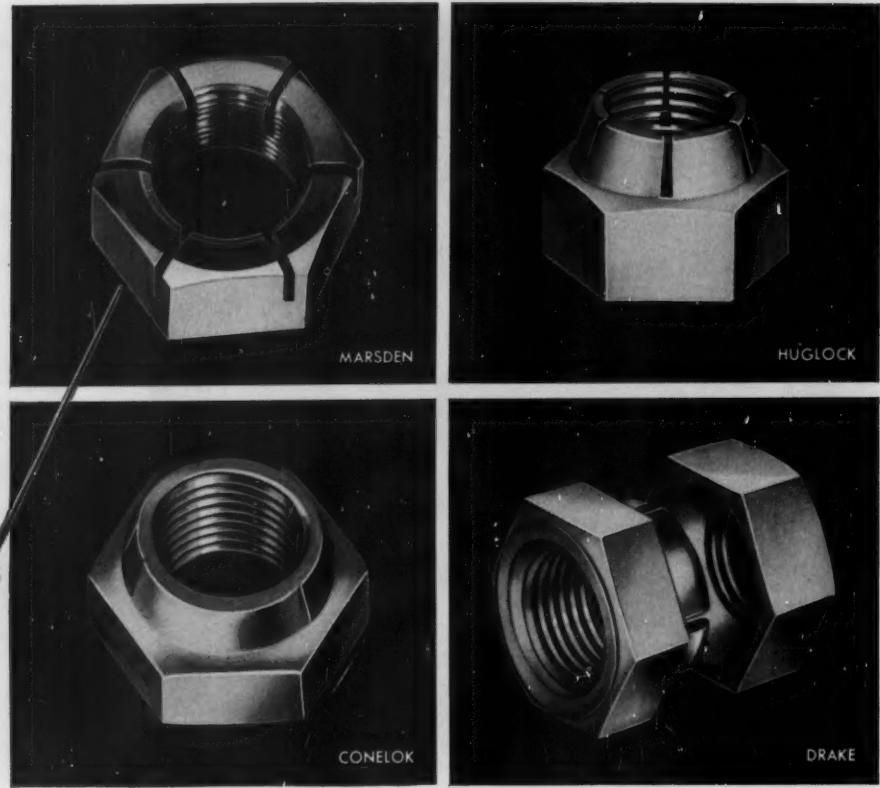
AviSun polypropylene is being used in new applications every day—from Pul-spirators to TV backs. New production facilities, now under construction, will soon be ready to meet the growing demand for this versatile new material. Send for Booklet AP-601, giving complete information on AviSun polypropylene.

AVISUN CORPORATION
Dept. 457
1345 Chestnut St.
Philadelphia 7, Pa.

*A trademark of AviSun Corp.



NAT'S
quick facts
about
Fasteners...



Looking for the **right** lock nut? Put these four high on your check list

By taking an early look at these National all-metal lock nuts, you may often be able to make quick work of finding the locking member that best meets the requirement of your particular job.

Once over lightly, here are the advantages they offer you.

MARSDEN—For minimum cost and average conditions. Free-running until seated. One-piece, fully re-usable.

HUGLOCK—For use under adverse conditions. Locks without seating. One-piece design, and fully re-usable.

CONELOCK—For applications requiring high-fatigue life, as assured by closed stress paths in Conelok's locking sections. Locks without seating. One-piece design, and fully re-usable.

DRAKE—For use under severe stress, shock or vibration. Free-running until seated, or can be locked at any point by using two wrenches. Two-piece design, and fully re-usable.

Take a good look at all four, and at the advantages they may be able to offer in your product assemblies. You may not be thinking of an application right now, but get the literature* and keep it handy in your files, just in case.

*There's a folder on the Conelok, and a booklet on the others. Write for your copies.



The National Screw & Mfg. Company • Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company

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ERIEZ Magnetic Minute

60 seconds that will help you improve operating efficiency.



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2. Magnamation® — the principles of permanent magnetism applied to automation, particularly pertaining to ferrous parts, cans, etc.
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Whether you're an equipment manufacturer or a direct user, our wealth of technical help is available to you. Write to Chief Engineer:

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131RA Magnet Drive, Erie, Pa.



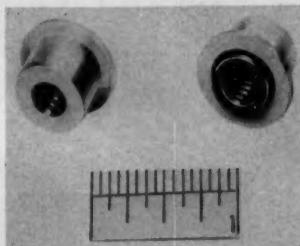
MAGNA-THOUGHT
Engineering field service is one of our prime assets. Eriez men in the field are always ready with the information, help, and counsel you may need.

C. Giermak
CHESTER GIERMAK
Sales Manager



Circle 344 on Page 19

NEW PARTS AND MATERIALS



gerined for a maximum pressure differential of 10,000 psi and a temperature range of -65 to +450 F. It is available in limited sizes from 1/4-in. shaft size. Hydrodyne Corp., 7352 Coldwater Canyon Ave., North Hollywood, Calif.

Circle 660 on Page 19

Plastic Cable Clamp

supports loads to 75 lb

New nylon clamp utilizes Nylatch fastener for support and clamping of wires, conduit, and cable. Clamp, which can be fastened and unfastened indefinitely, is a blind attachment since installation is made from one side of the supporting structure. Nylatch fastener is held captive in one arm of the clamp. Clamp is secured by pressing the plunger in, expanding the Nylatch grommet behind the supporting structure and locking the assembly. Unfastening is accomplished by lifting the plunger. Clamp sup-



ports loads to 75 lb and can be used in temperatures from -20 to +150 F. Hartwell Corp., 9035 Venice Blvd., Los Angeles 34, Calif.

Circle 661 on Page 19

Fractional-Horsepower Motor

for air-conditioners,
fans, and blowers

Type AR motor with 47/8-in. diam has high starting and running torques. A six-pole unit, motor is available with ratings from 1/20



ERIEZ Magnetic Minute

60 seconds that will help you improve operating efficiency.



HOW TO BUILD A PLUS INTO MATERIALS HANDLING EQUIPMENT

There's an Eriez Hi-Vi Vibratory Feeder to handle anything from powders to parts, rivets to rocks. If your problem involves feeding bulk materials of most any size, consider including Eriez Vibratory Feeders in your new designs for materials handling equipment.

Versatile, AC operated Hi-Vi® Feeders with 100% range of control, provide accurate, economical performance whether the application requires feeding a few ounces or many tons per hour.

Only Eriez gives you this exclusive combination of advantages: No bulky rectifier needed (AC operation) . . . Simple controls, less wiring and installation time . . . Totally enclosed drive, ideal for hazardous, dusty, wet, or corrosive conditions . . . New fibre glass springs assure superior performance and control, longer life because spring breakage is practically eliminated . . . Rugged construction withstands severe operating conditions.

Choose from many models for light, medium, or heavy-duty applications. For engineering data, write to:

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131RB Magnet Drive, Erie, Pa.



MAGNA-THOUGHT
Companies using Eriez components know we will remain faithful suppliers — not potential competitors.

R.F. Merwin
R. F. MERWIN
President



Circle 345 on Page 19

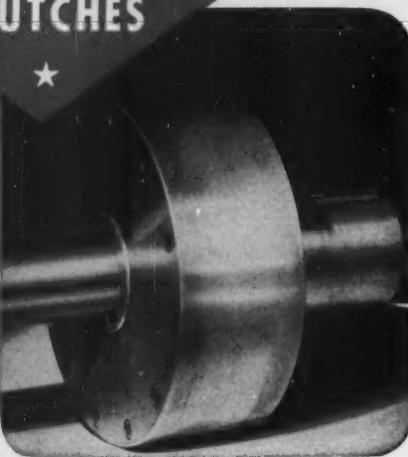
FOR POWER CONTROL DESIGNS USE
HILLIARD
Over-Running
CLUTCHES

1 LONG LIFE because the rolls have no localized wear points.

2 NO JAMMING even after long wear.

3 ACCURATE because of individual spring pressure on each roll.

4 RENEWABLE CAM SURFACES for increased life without machining or new parts.



50 YEARS of satisfactory service proves you can depend on Hilliard Over-Running Clutches and Couplings for long service on—

- DUAL DRIVES for pumps, fans, blowers and boiler stokers. (Many installations have a record of over 20 years without repair.)
- TWO SPEED DRIVES for dry cleaning machines, laundry equipment, conveyors, paper processing machines, slitters, forming rolls and automatic machinery.
- RATCHET ACTION for printing press ink rolls, coal feeders, press feeds, honing machines, bakery equipment and conveyors.
- BACK STOP SERVICE on textile machines, speed reducers, elevating conveyors and in combination with ratchet feeds.
- WRITE TODAY FOR BULLETIN 231 WITH COMPLETE INFORMATION.

OTHER HILLIARD CLUTCHES:

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

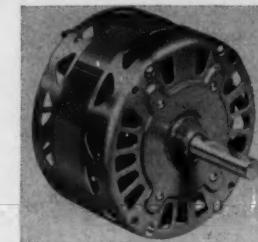
SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting, of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.

★ CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

THE HILLIARD CORPORATION
MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 W. FOURTH ST. ELMIRA, N. Y.
IN CANADA: UPTON • BRADEEN • JAMES, LTD.



through $\frac{1}{4}$ hp. It is suitable for a wide range of applications in the heating, refrigeration, air-conditioning, ventilating, and appliance industries. Redmond Company Inc., Owosso, Mich.

Circle 662 on Page 19

Ceramic Adhesive

bonds at up to 2600 F

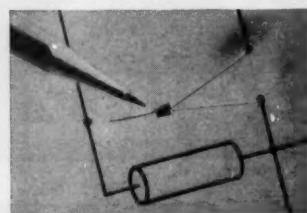
Melbond CA-100 ceramic adhesive has high bonding strength when used with refractory materials such as ceramics. It possesses a maximum service temperature of 2600 F after being cured at 250 F. It can also be used for coating items requiring high-temperature protection. Adhesive exhibits a loss tangent of less than 0.002 in. and a dielectric constant of approximately 1.9 in. when measured at room temperature. Special Products Div., Melpar Inc., 3000 Arlington Blvd., Falls Church, Va.

Circle 663 on Page 19

Silicon Transistors

double-ended units
dissipate 400 mw at 25 C

Double-ended subminiature silicon NPN transistors are electrically welded, hermetically sealed units designated 2N902 through 2N908. Dissipating 400 mw at 25 C, they are designed for use in ultracompact circuitry. Dimensions are 0.130 by 0.160 in., permitting a packing density of more than one million parts per cubic foot includ-



INDUSTRIAL RETAINING RING PRICES REDUCED UP TO 51%



Series 1000, Series 3000 and Series 3100 Industrial Retaining Ring prices—in quantities up to 100,000—have been greatly reduced.

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NEW CORED FORGING METHOD

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on parts
and
assemblies



This book describes the Bridgeport Cored Forging Process, and tells how weight, machining or assembly can be reduced on simple or complex parts.

Castings, ordinary forgings and assemblies have been economically replaced by these impact-type cored forgings to produce stronger and better looking finished parts. Savings range from significant to considerable.

<input checked="" type="checkbox"/>	closer tolerances
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Send for Bridgeport's Forgings Book which describes how these major benefits can lower costs for you.

CORED FORGINGS DIVISION
BRIDGEPORT
 BRASS COMPANY
 1000 Connecticut Ave., South Norwalk, Conn.

Circle 347 on Page 19

NEW PARTS AND MATERIALS

ing the space required for mounting. Units employ glass-to-metal seals, and operate in ambient temperatures from -65 to +175°C. Semiconductor Div., Raytheon Co., 215 First Ave., Needham, Mass.

Circle 664 on Page 19

Vertical Speed Reducers

nine sizes have ratios from 4 1/7:1 to 95:1

Vertical fan-cooled, worm-gear speed reducers are available in nine sizes from 3 to 12-in. center distances. Ratios extend from 4 1/7:1 to 95:1, and ratings are fractional to 175 hp. One-piece finned housings provide maximum strength and heat dissipation. Gear-shaft bearings are



grease-lubricated, with two fittings for each bearing. One fitting is used as indicator; grease flowing from it shows that the bearing is fully packed. Dry well around the output shaft and extending above the oil lever prevents oil seepage. Cleveland Worm & Gear Div., Eaton Mfg. Co., 3300 E. 80th St., Cleveland 4, Ohio.

Circle 665 on Page 19

Low-Capacity Pumps

handle almost any type of material

Type EA low-capacity, low-pressure pumps for such applications as domestic and commercial appliances handle almost any type of material from water-like liquids to abrasive slurries, including solids in suspension. Compact and quiet, pumps can be either belt driven or direct connected. Pumping action is smooth and free from turbulence, with positive displacement and continuous, uniform flow suitable for metering purposes. Smallest model offers ca-



Troublesome maintenance and lubricating problems are eliminated when you specify Thomas "All-Metal" Flexible Couplings to protect your equipment and extend the life of your machines.

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THOMAS FLEXIBLE COUPLING CO.
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Circle 348 on Page 19

OVER A BARREL ABOUT WHAT
POWER CYLINDER
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HERE'S WHY ANKER-HOLTH POWER CYLINDERS
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DIVISION, THE McDOWELL-WELLMAN COMPANIES

April 13, 1961

Circle 349 on Page 19

NINE COMPLETE LINES—THE MOST DIVERSIFIED
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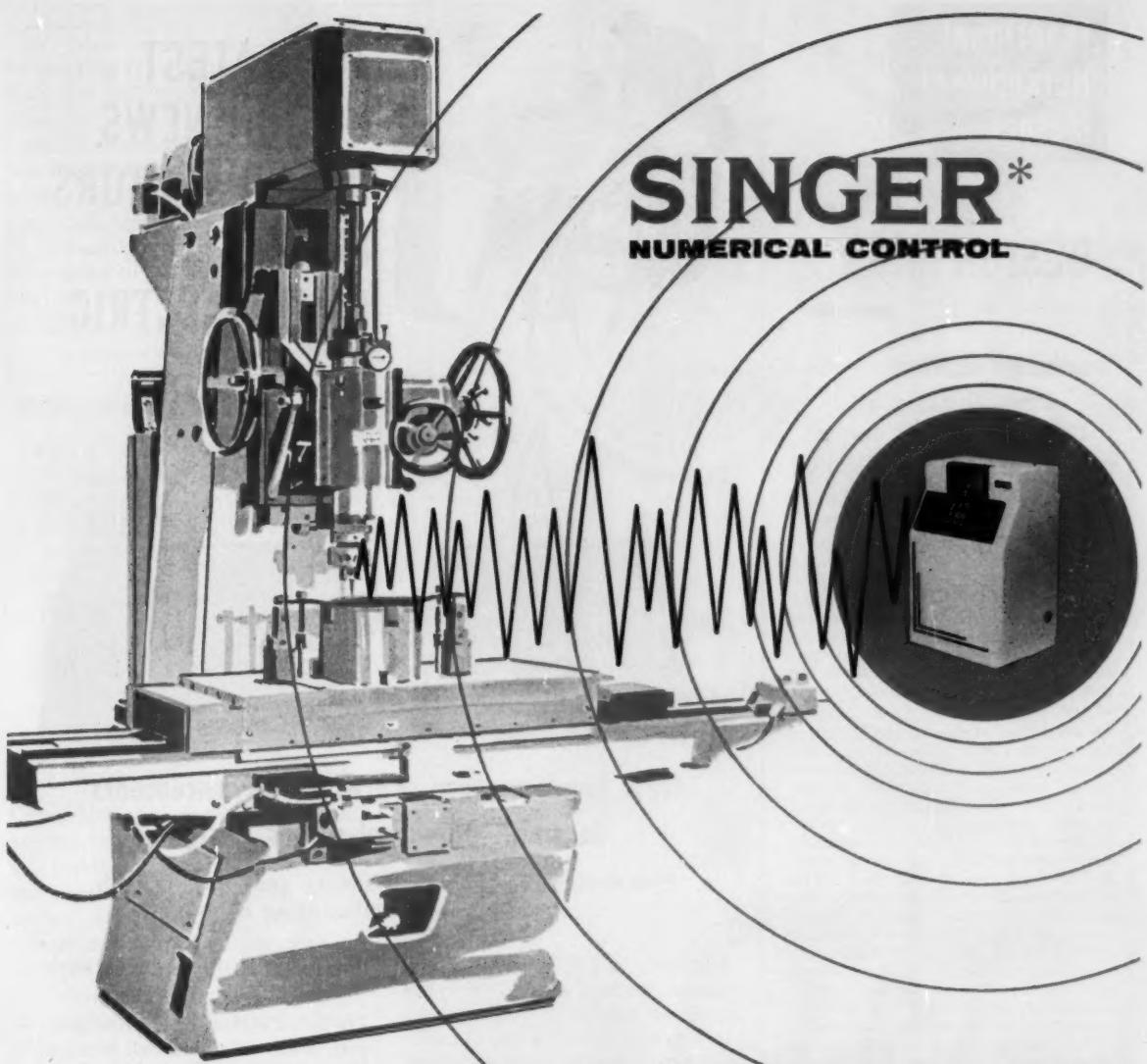
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A DYNAMIC NERVE CENTER FOR THE MACHINE TOOL INDUSTRY

A SINGER Achievement . . . the most direct approach to point-to-point positioning yet conceived. The SINGER Numerical Control System offers simplicity, reliability and economy, reducing costs of maintenance, labor and downtime.

DISCRETE POSITIONING: UP TO 40" OF TRAVEL, ACCURACY OF .001

SINGER Numerical Control makes possible a high degree of accuracy by a division of the measuring section and the motor drive within the system.

The SINGER System also features *modular design*, making

it possible to assemble basic units in a variety of control systems.

And, of prime importance, all modules and motors are designed, serviced and built by ~~Diehl Manufacturing Company~~, a SINGER subsidiary.

To see SINGER Numerical Control in action, visit the unique demonstration room at the Diehl Plant near Somerville, New Jersey. Here you can examine actual production records as evidence of the economy, reliability and accuracy of this advanced point-to-point positioning system. Call or write for an appointment at the address below.



DIEHL MANUFACTURING COMPANY

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Findern Plant, Somerville, New Jersey

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Fractional Horsepower Motors



Lamb Thinking on Universal Motors for a unique actuator application

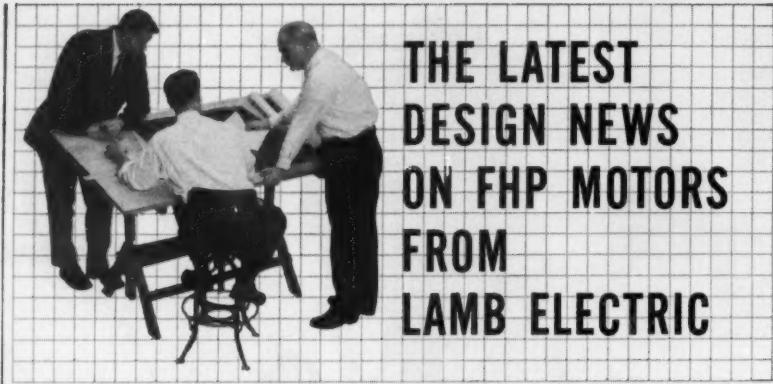
Here's what Lamb Electric designed into these motors:

In order to obtain the required speed and torques and retain the most economical and smallest package, a combination worm and spur gear reduction was used. Also, because of the peculiar space limitations in the application, special design considerations had to be given to the gear ratios and mechanical layout of the package.

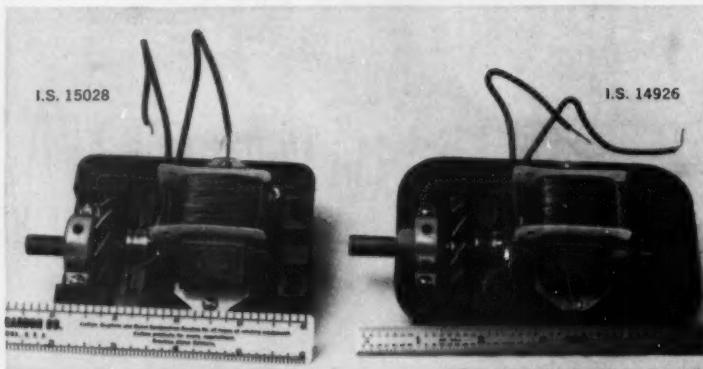
In the initial stages of the design a motor was provided which met the specified speed and torque requirements, however it was soon discovered that this design overheated rapidly. Analysis of the first prototype tests showed that the load cycle had a particularly high torque peak for a very short duration. The motor was designed to supply this amount of torque near its stalled speed. It was found that by taking advantage of the accelerating rate and starting torque of a universal motor, the motor accelerated quickly enough to provide sufficient inertial energy to complete the duty cycle. This enabled the engineers to redesign for a lower peak horsepower output and obtain reasonable operating temperatures, thus producing the minimum size package consistent with the torque and temperature requirements.

The application was such that severe shock loading was encountered at a certain point in the duty cycle. In order to make mechanical construction that would withstand this service, ductile iron castings were furnished and special consideration had to be given to the overhung moment of the motor-gear unit to insure against damage due to vibration. Special bearings had to be used in this service because Brinelling would occur on normal ball bearings under the severe service encountered. Lubrication is generally a problem under this short duty cycle, therefore, special consideration had to be given to insure that the lubricant protected the wearing surfaces at all times.

This is just a short example of Lamb at work . . . if you have a motor problem, let us help you with it. This is our business. Write: Lamb Electric, Kent, Ohio, and we'll have a Lamb District Engineer call on you to open preliminary discussion of your problem.



THE LATEST DESIGN NEWS ON FHP MOTORS FROM LAMB ELECTRIC



New Lamb motors represent advancements in small universal motor design

New design combines high quality and long life with relatively low manufacturing costs

Initially, the I.S. 15028 and companion motor I.S. 14926 were designed for powering rug agitators on a well-known line of canister-type vacuum cleaners. Now, many future appliance applications have been visualized. The range of ratings possible with this design (as high as 1/10 H.P. at 12000 RPM or 1/8 H.P. at 15000 RPM) makes this motor ideally suited for many motor powered domestic applications.

Some of the novel features of this motor project were:

The housing is a one-piece simple phenolic molding. It is designed in a half shell form in such a way that the motor bearings and other components can be held in accurate relationship with an unmachined housing.

The half shell housing of the motor is designed to mate with a corresponding opening on the customer's device to complete the motor enclosure. When a free standing motor is desired, this

upper enclosure can be a simple stamping.

The I.S. 15028 motor was designed with a sleeve and a ball bearing. However, on other versions of this motor, either sleeve or ball bearings or a combination can be used at only a low tooling expense through use of easily interchanged inserts in the housing mold cavity.

The sleeve bearing as used in this design takes full advantage of the economics possible with the half shell motor design. The full-spherical shaped self-aligning type of sintered bearing is mounted directly in a semi-spherical recess in the housing. A spring clip presses against the top of the bearing to secure it in place while at the same time permitting self-alignment movement. Life-time lubrication is provided by an oil soaked felt strip located beneath the bearing. There are other features worth noting in this unique design problem. For further particulars, write to Lamb Electric Co., Kent, Ohio.

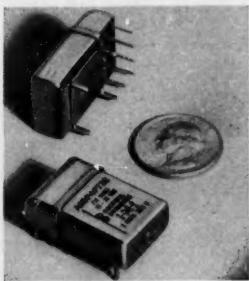
NEW PARTS AND MATERIALS

or pinching of wires in harness bundles, and also provides a true round diameter for retaining harness or conduit. Reinforcing ribs prevent bowing or weakening of the clamp at any point. Unit is impervious to nearly all corrosive liquids and fuels, is self-extinguishing, and will not deteriorate in salt air. Olympic Plastics Co., Inc., 3471 S. LaCienega Blvd., Los Angeles 16, Calif.

Circle 668 on Page 19

Microminiature Relay

Withstands high shock, vibration, temperature



Centipede relay for printed-circuit applications has a height of 0.44 in., making it suitable for military and commercial applications where vertical space is limited. Eight terminals and four mounting pins fit on 0.200-in. centers for standard printed-circuit grid mountings. Relay employs glass-to-metal hermetic sealing in combination with recessed leads set in high-resistance epoxy. Epoxy, in combination with an interlocking metal enclosure, inhibits the normal degrading effect of moisture. Unit resists vibration of 45 g at 5 to 2000 cps and has an ambient temperature range of -65 to +125 C. The DPDT unit is available in both voltage and current-sensitive models, in coil resistances from 0.1 to 11,600 ohms. Relay size is 0.4 x 0.8 x 0.875 in. Control Dynamics Corp., 7420 Fulton Ave., North Hollywood, Calif.

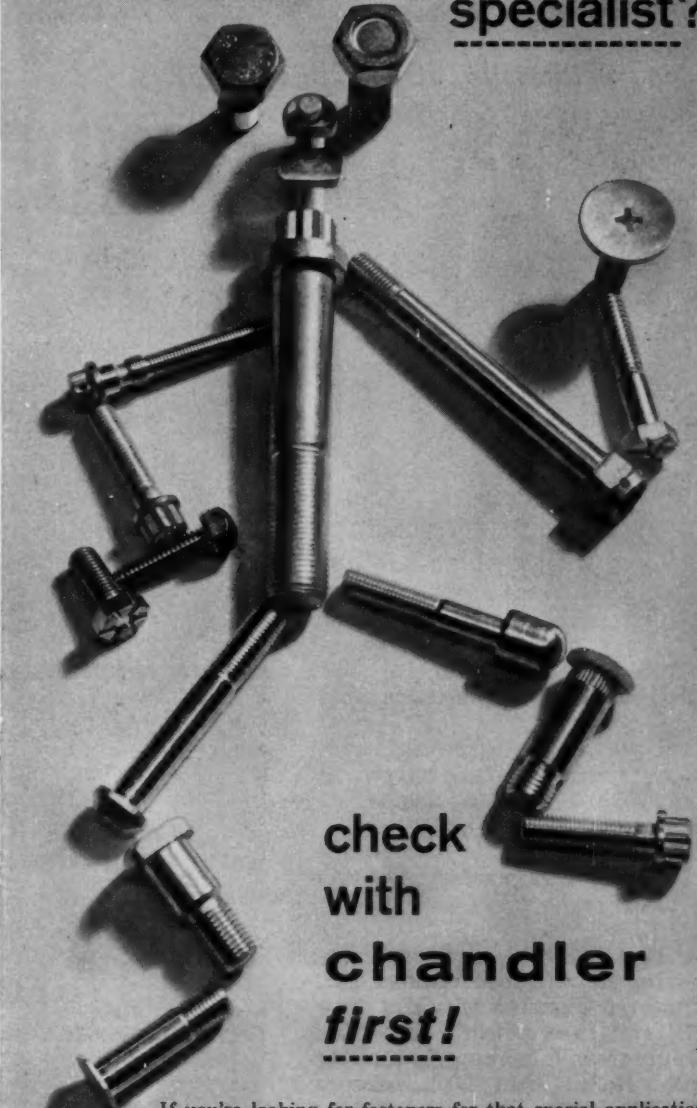
Circle 669 on Page 19

Ball Valve

for air and fluids
compatible with bronze

F-125 forged naval bronze ball valve incorporates Auto-Mating valve seats which provide positive

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first!

If you're looking for fasteners for that special application . . . fasteners that provide you with maximum reliability because they're precision-engineered, produced to strict tolerances and thoroughly tested . . . it will pay you to check with Chandler first! Here's why . . . Chandler has specialized for over thirty years in producing high quality special fasteners . . . as well as standard cap screws and bolts to meet rigid aircraft, military and industrial standards. Design features of these cold-headed fasteners include special heads, shanks or threads . . . drilled, rolled, ground, plated or coated . . . plus controlled atmosphere heat treating . . . to comply with your requirements.

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Circle 354 on Page 19

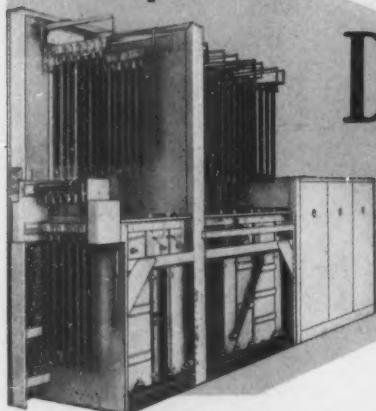
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Automatic FILMACHINES

... synchronized throughout by

DIAMOND

ROLLER CHAINS



specified for accuracy
and uniform high quality!

- ① On exact, predetermined time schedule, DIAMOND Chain powered transfer arms on elevator bar shift film hangers to next processing tank.
- ② DIAMOND Chain powered "saw-tooth" tracks (A) move hangers at precisely one tooth per minute.
- ③ DIAMOND Chain synchronizes film dryer with processor; delivers a hanger of dry film each minute.
- ④ Rear of PAKO Automatic Filmachine shows speed reducer (A), DIAMOND Chain transfer arm drive (B) and "saw-tooth" drive (C). Counterweights slung from DIAMOND Roller Chain (D) help insure smooth elevator bar operation.

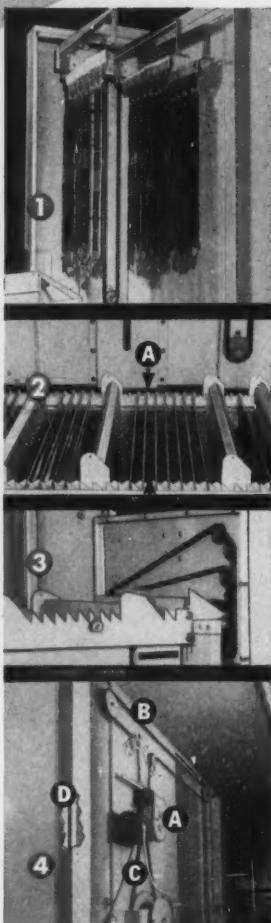
PAKO Automatic Filmachines, manufactured by the PAKO Corporation of Minneapolis, Minnesota, process and dry up to 420 rolls of black and white film per hour. Color machines handle up to 300 rolls per hour. All units are equipped with DIAMOND Roller Chain.

DIAMOND Chain offers many opportunities to solve timing, conveying, and power transmission problems. Call your DIAMOND Distributor or write direct to DIAMOND CHAIN COMPANY, INC., A Subsidiary of American Steel Foundries, 402 Kentucky Avenue, Indianapolis 7, Indiana.

Offices and Distributors in
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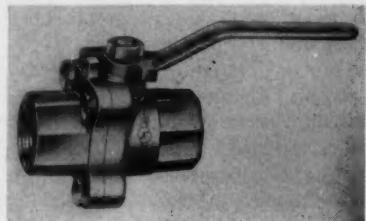
DIAMOND

ROLLER CHAINS



Circle 355 on Page 19

NEW PARTS AND MATERIALS



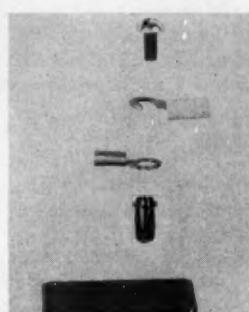
sealing in either flow direction throughout the life of the valve. Spring, retainer ring, and O-ring seal behind valve seat provide constant compression, self-adjustment, and a tight seal. Valve is available for general use with air, water, oil, gas, or fluids compatible with bronze. Ball Valves Inc., 41 Jackson St., Worcester, Mass.

Circle 670 on Page 19

Threaded Insert

makes electrical connection
in molded plastic

Dodge expansion insert, designed to provide durable brass threads in molded plastic, is available in a new type which provides electrical connections. Clinch Insert is suited for such molded plastic parts as terminal blocks, switch components, and related electrical parts. An eyelet, which protrudes above the surface of the workpiece, is the primary feature of the insert. Terminal or contact strip is placed over the eyelet and then eyelet is crimped over the terminal, forming a strong, conductive electrical connection. Lead wires can then be attached to the connection by a binding screw threaded into the insert. Insert provides substantial strength when properly installed. It is available from stock in sizes 4-40 through 8-32 with 0.040 and 0.064-in. eyelet heights which accommodate terminals with No. 6 through No. 10.



MOTORS BY THE POUND?



You're buying motors by the pound when price is the only consideration

Sure, you can get a motor for the lowest price, a motor of the same type and with the same rating and operating characteristics of the highest priced motor. But, while initial price is an important factor, the actual cost is the ultimate cost of a motor. And, ultimate cost includes the repair bills, lost production, lost man hours and lost customers that an inferior, built-down-to-a-price motor could cost you.

Wagner® protected polyphase motors do cut expensive downtime. Their cast iron frames can't be affected by corrosive acids, salts, or alkalies. They are designed for cool running...stator temperatures stay low to in-

crease motor life. Wagner polyphase motors are designed to permit relubrication that adds years to motor life under severe operating conditions. Wagner motors have earned a reputation for proven dependability.

Next time you buy motors, check beyond the purchase price. Make sure that you get all the performance you need—with motors that will do the job.

Wagner motors have been getting the job done for more than 65 years. Your Wagner Sales Engineer will be glad to show you why. Call him for an analysis of your next motor application, be it for plant or product.

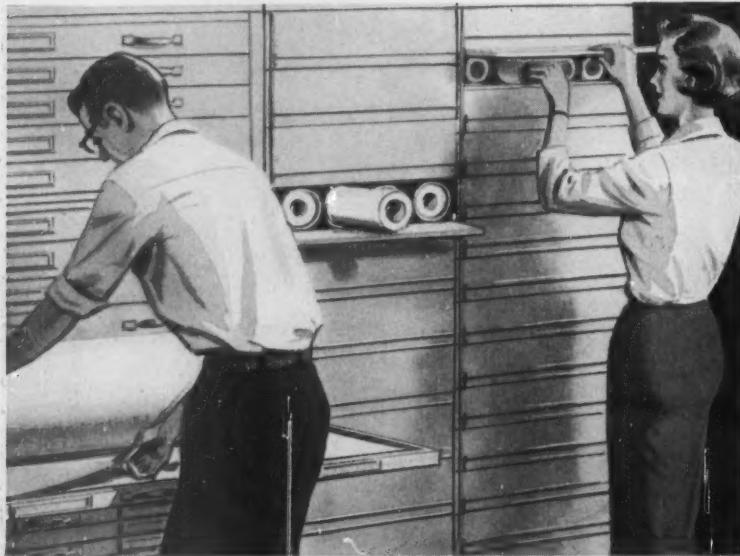
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Wagner Electric Corporation

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Greater protection and accessibility for roll tracings than ever before possible!

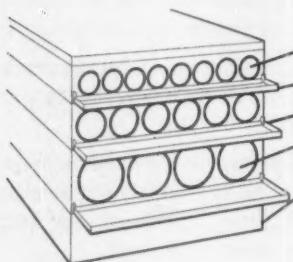


NEW Hamilton MODUCOR Roll Tracing File

New Flexibility—MODUCOR Roll Tracing Files come in 8, 6, and 4-tube modules. Any combination may be stacked in *self-supporting* units as high as space allows. Also designed for symmetrical stacking adjacent to Hamilton Unit System Files.

New Accessibility—These Hamilton-engineered file units have spring-loaded doors that stay either open or closed. Units may be stacked so upper level file doors open up... while lower level doors open down. Label holder runs full length for easy identification.

New Protection—Foil-covered tubes encased in steel frame assure moisture, dust, and smoke resistance for valuable tracings.

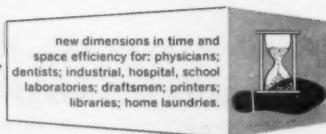


- Select from 1 1/8", 2 1/8", or 4" tube diameters for filing flexibility
- Full-length label holder
- Spring-loaded door, full length
- Steel-rimmed, foil-covered tubes
- Rigid base

WRITE TODAY for illustrated brochure on Hamilton MODUCOR—the most practical Roll Tracing Files on the market.

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PROFESSIONAL AND SCIENTIFIC FURNITURE

Hamilton Manufacturing Company, Two Rivers, Wisconsin



NEW PARTS AND MATERIALS

holes in popular thicknesses. Phelps Mfg. Div., Heli-Coil Corp., Danbury, Conn.

Circle 671 on Page 19

Synchronous Motor

has starting and synchronous torque of 0.70 oz-in.

Precision synchronous motor with 1 1/8-in. diam and 2 1/8-in. length is available for operation on 24 v, 60 cps. It can also be supplied with windings to operate on other voltages to 300 v, 60 cps. Operating at



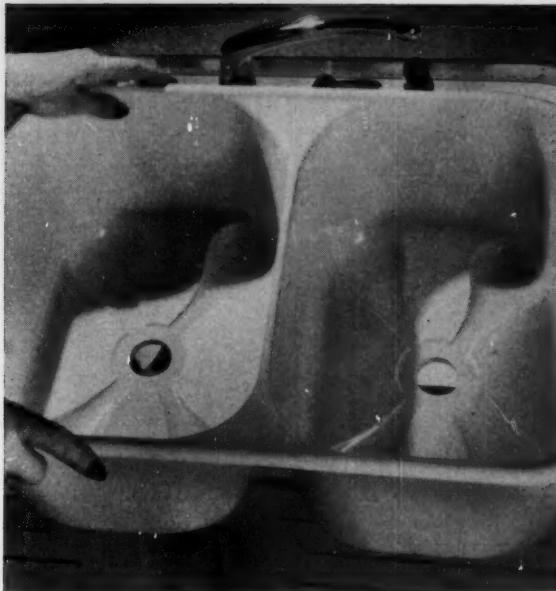
a synchronous speed of 1800 rpm, motor has a starting and synchronous torque of 0.70 oz-in. It is operative over an ambient temperature range of 0 to +140 F. Corrosion-resistant construction provides high resistance to moisture, shock, and vibration. Lifetime-lubricated ball bearings are incorporated. Weighing 7 oz, motor operates on 12.5 w. Applications include dictating and recording devices, timers, and controls, wherever constant-speed drive is required. **Instrument Div., Thomas A. Edison Industries, West Orange, N. J.**

Circle 672 on Page 19

Indicator Tubes

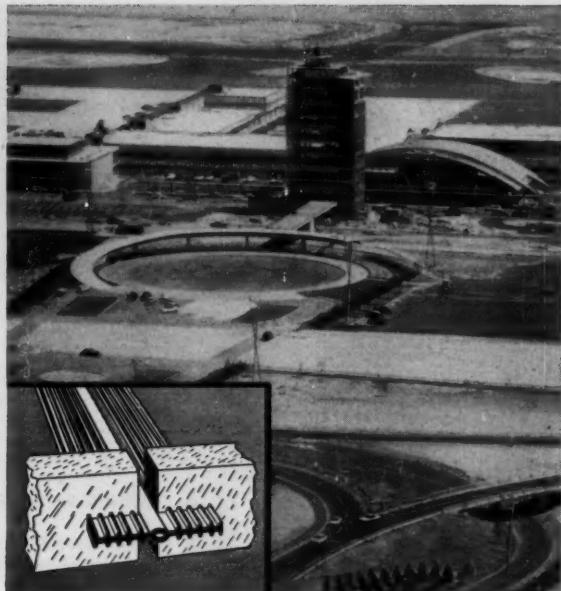
have 160-deg viewing angle

New Nixie indicator tubes feature a flattened tube face and cutaway anode which permit higher positioning of cathode numerals. Changes have increased the viewing angle of the tubes from 90 to 160 deg. Standard type B5092 features 6/10-in. characters having a viewing distance of 35 ft under normal conditions. Type B6091 has 8/10-in. characters and is readable to 40 ft.



PROBLEM: IMPACT STRENGTH, with acid, alkali and heat resistance—Lightweight, one-piece, dual-compartment sink trays vacuum-formed from BAKELITE high-impact styrene offer housewives and photo developers the convenience of two identical basins in a single sink area. Available in white and colors, they are easy to keep clean and withstand bleaches, common acids, detergents and photo developing solutions. Weighing only 1½ lbs., the tray has a low unit cost.

The manufacturer of this patented dual sink insert, Goodhousewares Products Company, Los Angeles, Calif., chose extruded sheets of BAKELITE high-impact styrene only after other plastics were tested and failed to withstand "daily-use" tests.



PROBLEM: WATERTIGHT JOINTS that are flexible—The tough flexible waterstop extruded from a BAKELITE Brand elastomeric vinyl plastic compound stops moisture penetration through the joints in concrete walls and floors in the new buildings at International (Idlewild) Airport, N. Y., N. Y. This multiple ridge waterstop or joint membrane is inserted in the construction forms prior to pouring as a joint barrier. The lifetime flexibility of BAKELITE vinyl virtually assures against leakage due to fatigue, breakage, oxidation or chemical deterioration. Electrotrot Inc. manufacturers of this "Durajoint" waterstop pioneered this application of plasticized vinyl. They have always specified BAKELITE Brand vinyls for all waterstop extrusions.

Extruded plastics for solving design problems



PROBLEM: DIMENSIONAL STABILITY, plus good looks and toughness—The spare tire cover of Ford Motor Company's "Comet" and "Falcon" station wagons is designed to be an integral, though removable, part of the interior body and decor. Thus, excellent dimensional stability is needed to avoid shrinking and warping despite rough handling or changing seasonal temperatures.

Extruded sheets made from BAKELITE Brand high-density polyethylene and vacuum-formed to exact dimensions were chosen for this application. In addition to stability and ease of fabrication, BAKELITE high-density polyethylene is light in weight, with excellent rigidity, toughness, heat resistance and stress-cracking resistance. And, it is available in a wide range of colors. Remember, too: there's variety in BAKELITE polyethylene—with low-, medium-, and high-density formulations. You can use our broad experience to find out which meets your needs best.

Here's how other design engineers used them to solve problems of cost and performance

Take a look at the various products pictured here . . . study the design problems of each . . . see how all were effectively solved. Do you find some similarity between these and your own design problem?

A particular BAKELITE Brand resin may be just the plastic you need. You have a wide range of choice—polyethylenes, epoxies, phenolics, styrenes, vinyls—all of traditionally high UNION CARBIDE quality. See your Sweet's Product Design File, Section 2a/ui, for properties. Or, for more detailed information, just mail the coupon.

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.



Dept. JH-84D, Union Carbide Plastics Company
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N. Y.

Please send me information on BAKELITE resins and suggested applications. I am especially interested in:

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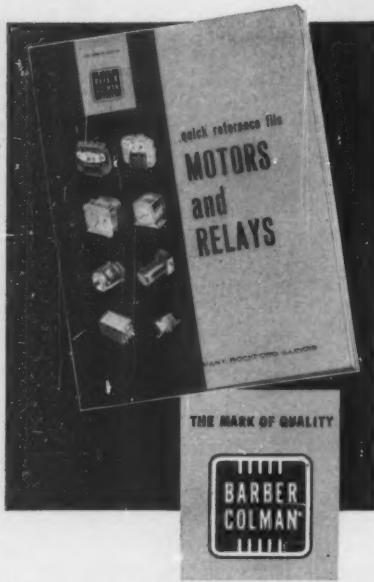
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quick reference file...a-c and d-c small motors, tach generators, relays...



Get this helpful quick reference file that illustrates and gives typical specifications for the wide selection of Barber-Colman small motors (to 1/10 hp), relays and related components for electronic applications. Here you'll find many practical solutions to complex control problems . . .

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unidirectional • reversible
synchronous • geared

A-C and D-C TACH GENERATORS

D-C PRECISION MOTORS

BATTERY-OPERATED MOTORS

A-C 400-CYCLE MOTORS

BLOWERS, GEARHEADS

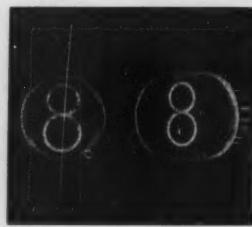
ULTRA-SENSITIVE RELAYS

Send for your copy Quick Reference File F-9765.

BARBER-COLMAN COMPANY
Dept. P, 1973 Rock Street
Rockford, Illinois

Circle 359 on Page 19

NEW PARTS AND MATERIALS



Third tube, a large size unit, has 1 1/8-in. characters and is designed for viewing to 60 ft. Electronic Tube Div., Burroughs Corp., Plainfield, N. J.

Circle 673 on Page 19

Stainless Steel

free-machining type has high corrosion resistance

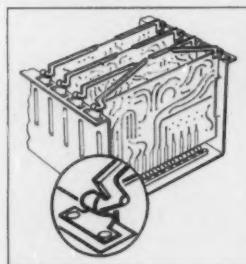
Uniloy 303MA, new free-machining, chromium-nickel stainless steel has excellent surface finish and high corrosion resistance. Combination of aluminum and sulfur additions for good machinability makes possible a reduction in sulfur content to about one-half that in AISI Type 303. Material can be arc welded, flash welded, percussion-stud welded, and brazed. It is available in standard bar sizes in rounds, squares, hexagons, and in forging billets, forgings, plates, sheets, strip, and wire. Universal - Cyclops Steel Corp., Bridgeville, Pa.

Circle 674 on Page 19

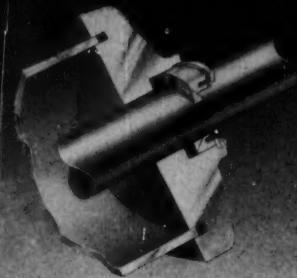
Printed-Circuit Fastener

has 8 to 1 lever ratio

Designed for rapid injection-ejection of printed-circuit boards, fastening device supplies mechanical leverage to set up or break a circuit. Lever which pivots from the corner of the circuit board engages a spring attached to the chassis. Two fasteners are used for each board, so that raising the lever arms auto-



**Packs more
PERFORMANCE
into less space**



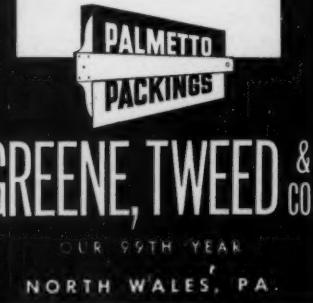
THE PALMETTO ^D SEAL

Patents Issued and Applied For

Palmetto offers a compact, low-cost rod seal which matches the performance of the best grades of bulkier packings. You save significantly on machining costs . . . packing cost is reduced . . . sealing action is sure, unusually long-lived.

- **POSITIVE SEAL . . . NO "SPIRALING"**—with stable D-ring
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- **INCLUDES SCRAPER-WIPER**—lip on outer wedge is integral wiper
- **FITS SIMPLE COUNTER-BORE IN CYLINDER HEAD**—is secured with snap ring

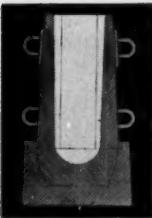
Write for details now, and see the D-W Seal at Greene, Tweed's Booth #105 at the 1961 Design Engineering Show.



Circle 360 on Page 19



MEL-TROL®...the important extra you get in *Carpenter* Induction Vacuum Melted Alloys!



New, more refined melting processes such as Carpenter's VACUMELTROL® (induction vacuum) or CONSUMET® (consumable electrode) answers industry's need for better, more dependable steels for critical applications. But in induction vacuum alloys, Carpenter goes a step further. It's called MEL-TROL and it starts with an entirely new, patented mold that builds essential core-to-surface uniformity right into the ingot. Harmful impurities in the molten steel float to the top while the ingot solidifies . . . then are discarded. The result is more complete freedom from segregation and centerline weakness, and the most uniform, dependable alloys you can buy.

Benefits to you: Improved alloy quality such as cleanliness and soundness result in better forgeability, improved machinability and cold forming properties. You get more accurate forgings with better finishes . . . fewer rejects . . . faster production . . . and, most important, true predictable performance in critical alloy components. A wide range of these more uniform, more workable alloys is now available for high temperature and other critical applications. Call your nearby Carpenter representative for the whole story about MEL-TROL and what predictable performing steels can do for you.

Carpenter steel

you can do it **consistently** better with Carpenter Specialty Steels for specialists



The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.



Save on any size rings with Amweld

Amweld makes flash butt-welded rings in diameters of four inches to eight feet and offers ring customers a sizable cost reduction in every case. Amweld rings save on metal, because rings are formed to or near finished dimensions. Amweld rings save on machining, because the metal is left out—not hogged out. Important to you, Amweld can flash weld rings from almost any metal alloy, common or exotic.

Savings to all Amweld customers totaled over one million dollars last year. One Amweld customer saves by using Amweld rings as gear blanks. Another saves by using Amweld rings as tank flanges. A third saves on rings for jet engine applications. It doesn't cost a thing to think on paper with Amweld. So let us quote you for your cost comparison. Write today: The American Welding & Manufacturing Co., 901 Dietz Road, Warren, Ohio.



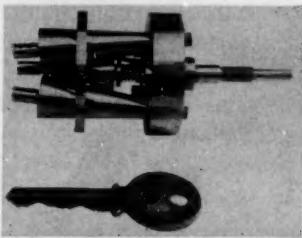
THE AMERICAN WELDING & MANUFACTURING CO., WARREN, OHIO

matically ejects boards from its socket. Lowering the arm pushes the board back toward the socket, completing the circuit and locking the board in place. With an 8 to 1 lever ratio, fastener enables boards to be replaced in seconds. Spring and lever are SAE 1070 steel, cadmium plated, rivet is stainless steel. Southco Div., South Chester Corp., Lester, Pa.

Circle 675 on Page 19

Adjustable-Speed Transmission

miniature unit is for instrument and control uses



Miniaturized adjustable-speed transmission is available for use in instrument and control applications to $\frac{1}{8}$ hp. Three types are offered: One delivers all speeds from any desired maximum to zero; a second delivers speeds from maximum to zero and into full reverse without change of input rotation; a third can be connected to give output speeds that vary approximately ± 10 per cent from a given input speed. Entire drive, including precision lead-screw control, can be enclosed in a housing approximately $2 \times 2\frac{1}{2} \times 3\frac{3}{4}$ in. long. Transmission is readily adapted to servo motor input and to precision gear-train reducer assemblies. Transmission provides inherent overload protection. Graham Transmissions Inc., Menomonee Falls, Wis.

Circle 676 on Page 19

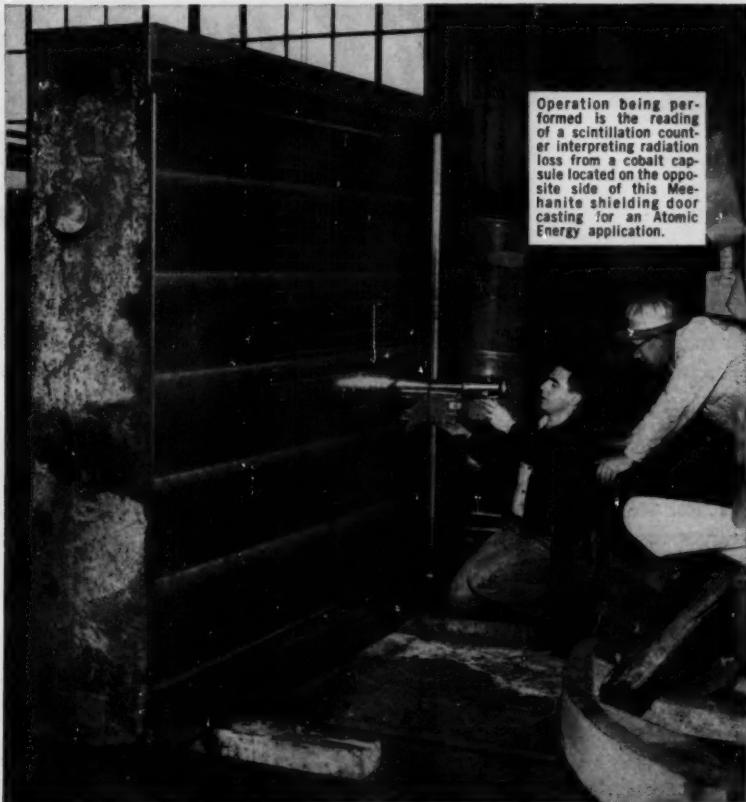
Miniature Terminal Boards

can be shaped to fit specific requirements

Miniature terminal boards on 0.100-in. grid patterns in any shape are now available. Glass-filled epoxy, melamine, or silicone insulation is used, and board shape can be formed to fit equipment. Terminals are

(Please turn to Page 250)

MEEHANITE® MEANS BETTER CASTINGS



Operation being performed is the reading of a scintillation counter interpreting radiation loss from a cobalt capsule located on the opposite side of this Meehanite shielding door casting for an Atomic Energy application.

Specify Meehanite® For High Density And Solidity In Heavy Sections

Dimensions of the 85,000 lb. Meehanite casting above are 12'6" x 12'6" x 12" thick. Specific gravity tests, ultrasonic and radiation loss readings verify its uniform and controlled density.

In massive castings of this type which have a slow cooling rate, there is a natural tendency towards a more open structure with a corresponding loss in strength. However, in Meehanite castings the effect of "mass influence" is minimized through the use of constitutional carbide controls which are exclusive to the Meehanite Process. Breakdown of structure due to slow cooling is avoided by providing a definite degree of undercooling of the graphite to the melt.

In specifying the correct type of Meehanite metal for castings with very heavy or very light sections, the effect of mass influence should always be considered.

For detailed information, send for a free copy of bulletin TD-14-EFFECT OF MASS INFLUENCE. Write: Meehanite Metal Corp., New Rochelle, N.Y.



MEEHANITE METAL

Meehanite Castings Are Made Only By Meehanite Foundries

SYLVANIA SHAVES COSTS FOR SCHICK-IN PLASTICS, METALS AND ASSEMBLIES

Producing the switch for a compact, 3-speed electric razor leaves almost no margin for error. It must be precisely built and still withstand the punishing abuse of day-to-day handling.

In making the switch for the new Schick razor shown below, Sylvania Parts Division meets these requirements. Our experience with a wide range of materials resulted in better electrical contacts. And our

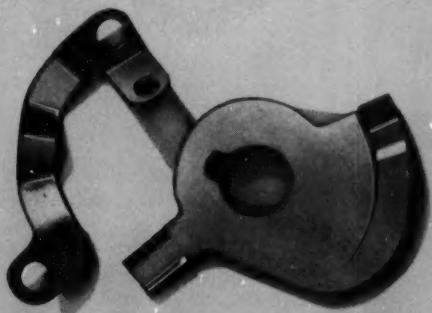
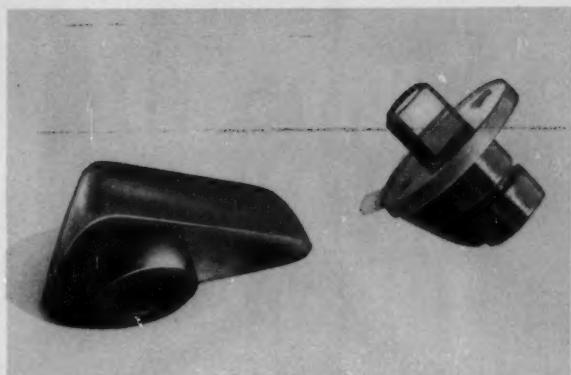
facilities assure durable, precision parts and assemblies as well as high-speed production. The combination means important economies to Schick.

For details, see captions at the right. For full information on how Sylvania custom parts facilities can benefit you, or for a quote on a specific project you have in mind, write Sylvania-Electric Products Inc., Parts Division, Warren, Pennsylvania.



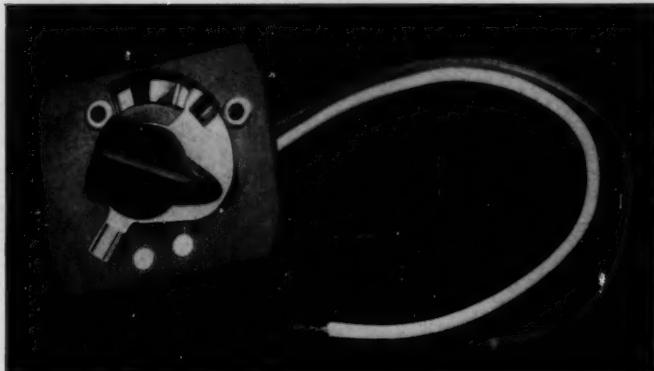
MOLDED FROM PLASTIC are parts for the switch assembly. Each must meet the tightest specifications. Example: Sylvania molds shaft and selector button from nylon, holds dimensions on both to a height and diameter of $\pm .0015$ ". In addition, the flash is controlled to $1/32$ " because the button is a snap fit on the shaft. Since Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment, it can handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to Schick? Precisely molded parts—in volume!



CUSTOM METAL STAMPINGS also proved important to Schick. Sylvania recommended changing the selector detent and rotor to brass, thus permitting a reduction in thickness from $.015$ " to $.010$ " and assuring an improvement in contact from rotor arm to detent. Sylvania made the dies necessary to produce these parts. The Sylvania metal stamping facility includes multi-slide machines, vertical presses and specially developed machines to help solve your problems.

Result to Schick? Positive electrical contacts assured while a 5° offset on the selector rotor is maintained to within $\pm 1^{\circ}$ day in and day out.



CUSTOM ASSEMBLY by Sylvania of the switch assembly is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or a combination of some Sylvania and some customer supplied—at lower cost than is possible in the customer's own facilities.

Result to Schick? Thousands of completed, durable and precision assemblies per month.

NEED CUSTOM WELDING OR WIRE? Sylvania supplies both. To help you meet your welding needs, Sylvania has developed new high-speed, high-volume techniques and advanced welding equipment—automatic and semiautomatic. To help you with wire, only Sylvania of all major manufacturers makes all three types of bare wire—alloy, clad and plated. They're available in a full range of sizes, too— $.002$ " to $.250$ ". Where necessary, Sylvania will precision-roll wire into ribbon connectors that offer high reliability when the circuitry calls for wire wrap contact methods.

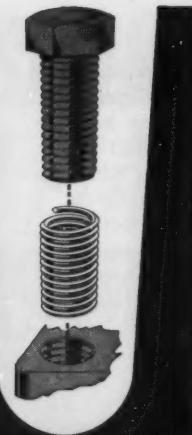
SYLVANIA

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS



3 WAYS TO PERMANENT THREADS - IN ANY MATERIAL!

For original design — production salvage and "on-the-job" thread repairs — use *Heli-Coil* Stainless Steel Wire Screw Thread Inserts.



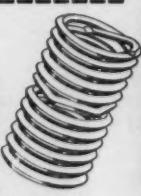
HELI-COIL Standard Insert for stronger, smoother, lifetime threads

Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration, and shock. Made of 18-8 stainless steel wire, this precision-formed *Heli-Coil* Insert has a tensile strength of approximately 200,000 psi. Conforms to military standards and all commercial and industrial thread forms.



HELI-COIL Screw-Lock Insert eliminates lock wiring and lock nuts

This one-piece wire Screw-Lock Insert provides all the thread protection of the Screw-Thread Insert, PLUS an exclusive resilient *internal* locking feature that eliminates clumsy protruding lock nuts, lock wiring and other supplementary locking devices. It saves cost, space and weight — permits simple streamlined design in standard bosses. Meets military and N.A.S. specifications for locking torque and vibration.



HELI-COIL Shop-pack for all "on-the-job" thread repairs

Contains everything needed for fast, easy thread repair — *on the spot!* Salvage expensive parts — for pennies! Shop Pack restores threads to original size. Available in U.N.F. and U.N.C. sizes 6-32 to 1½-6. There's a kit for spark plug and pipe thread sizes, too. Each Shop Pack contains a supply of *Heli-Coil* Screw-Thread Inserts with special tap plus inserting tool.



There is a *complete* line of *Heli-Coil* products for every thread need: inserts, taps, tools and gages. Let us help with your design and application problems. Write today for complete information.

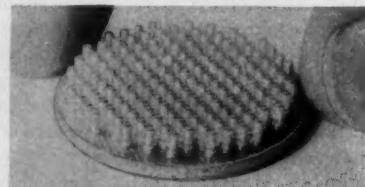


HELI-COIL CORPORATION
504 Shelter Rock Lane, Danbury, Connecticut

© 3103

NEW PARTS AND MATERIALS

(Continued from Page 247)



brass, phosphor bronze, or beryllium copper. Printed circuitry as an integral part of the board can be supplied. Pictured is a typical part containing 100 terminals per square inch. Accurate Electronics Corp., 169 S. Abbe Rd., Elyria, Ohio.

Circle 677 on Page 19

Switch Light

permits rebulbing without special tools

Twist Lite permits rebulbing and changing of color, lens, or legends without use of special tools. It is designed for commercial or military applications. Completely assembled units or separate assemblies are available. Mounting may be vertical, horizontal, or matrix. Switches clip to rear of unit for ease of maintenance. Each unit accepts four industry type 327 bulbs, and has corrosion-resistant bulb contacts. Display area can be split horizontally or vertically. Engraved legend per customer specifications available. Unit resists shock of 20 g for



10 millisec in all three planes, and resists vibration of 10 g to 500 cps. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif.

Circle 678 on Page 19

Cushion Clamps

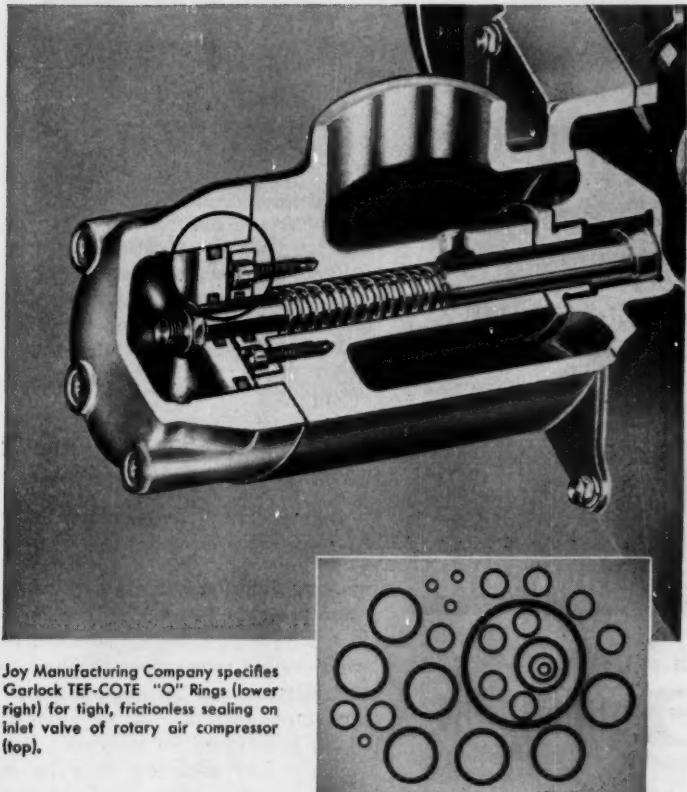
resist temperatures to 1500 F

TA 1500 lightweight cushion clamps are type 321 stainless steel. They resist temperatures to 1500 F.



ENGINEERED TEFLON PRODUCTS

for Hydraulic, Pneumatic
Service



Joy Manufacturing Company specifies Garlock TEF-COTE "O" Rings (lower right) for tight, frictionless sealing on inlet valve of rotary air compressor (top).

Garlock TEF-COTE "O" Rings stop air leakage—without slip stick and adhesion—on Joy portable compressors.

During exhaustive tests of 500,000 cycles at a 1" stroke, TEF-COTE "O" Rings proved completely satisfactory for operation on Joy two-stage rotary portable air compressors supplied to the Corps of Engineers. As plunger seals on the inlet valve, the rings seal pressures to 40 p.s.i., temperatures from +90°F to +120°F on a rotary shaft moving at 30 cycles per hour.

To minimize cylinder breakaway friction, chattering or freezing, do as the Joy Manufacturing Company has done. Investigate the possibility of Garlock TEF-COTE "O" Rings on hydraulic and pneumatic valves and cylinders, and valve stems. TEF-COTE "O" Rings—solid rubber, coated with Teflon†—offer a fine combination of low breakaway and low running friction. Garlock also offers "O" Ring Packings of solid Teflon for exceptional antifriction sealing at temperatures from -100°F to +500°F. Where unidirectional pressures are encountered, specify Garlock slotted "O" rings of Teflon—they are designed for simple installation into standard AN grooves. When you design fluid power equipment, consider using Garlock "O" Ring Packings. They are available in many sizes and materials—nitrile, butyl, silicone, and Viton† rubber and Teflon to meet your needs. For application recommendations, consult your local Garlock representative. He is backed by years and years of experience in the design, manufacture and application of packings and seals of all types. Call him at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalogs AD-148 and AD-157. Garlock Inc., Palmyra, N. Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastics Products.

†DuPont Trademark



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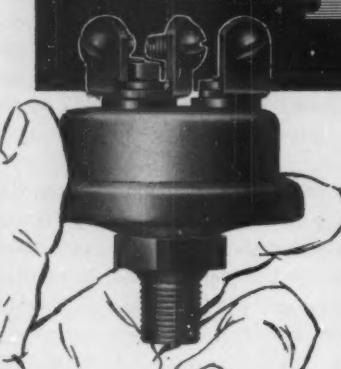
Member of Plastic Planners

*Du Pont Trademark
© Reg. TM G.E. Co.



Circle 367 on Page 19

**Hobbs DUAL CIRCUIT
PRESSURE SWITCHES**



**Add a NEW
DIMENSION
to Pressure Activation!**

**A COMPLETE LINE OF
PRESSURE SWITCHES**

Also available — a wide selection of single circuit pressure switches. Built by the manufacturers of Hobbs Running Time Meters and Shock-Mounted Head Lights. Distributors in principal cities. Write for CATALOG PS605

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Excellence**

John W. Hobbs Corporation
A DIVISION OF STEWART-WARNER CORPORATION
9051 YALE BLVD., SPRINGFIELD, ILLINOIS

Circle 368 on Page 19

NEW PARTS AND MATERIALS

Cushion is corrugated to furnish a spring action for high-frequency, low-amplitude vibration. Clamps are available in sizes from $\frac{1}{4}$ to 4 in. ID, and are interchangeable with any standard $\frac{1}{2}$ in. AN, MS, or commercial-type cushioned loop clamps. Corrugated cushioning has flat surfaces for maximum tube contact and dissipates heat by utilizing convection, conduction, and radiation. Cushioning is spot-welded to the clamp, and cushion edges



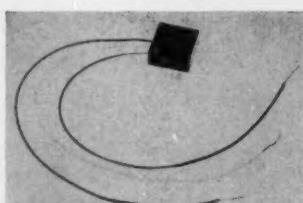
are crimped for abrasion-free grip. When installed, clamps are impervious to corrosion, and have a minimum amount of wicking when exposed to fluids. TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

Circle 679 on Page 19

Subminiature Potentiometer

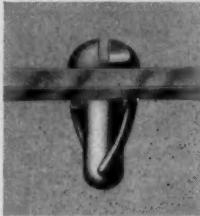
has operating temperatures
from -55 to $+200$ C

Squaretrim Model 355 high-temperature precision trimming potentiometer is $\frac{1}{2} \times \frac{1}{2} \times 0.2$ in. size. Resistance values range from 10 ohms to 50 kilohms over an operating temperature range of -55 to $+200$ C. Unit is designed for matching, balancing, and adjusting variables in all types of precision control, computing, and telemetering circuits. The square shape permits stacking of as many as twenty 50-kilohm potentiometers in 1 cu in. Circular design of the mandrel permits use of a long resistance winding to produce high resistance values. Worm-gear adjusting device provides high-



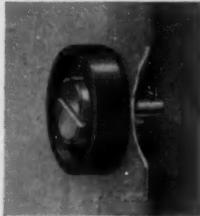
How can you use SPRING-LOCK?

THE FASTENER WITH USES UNLIMITED



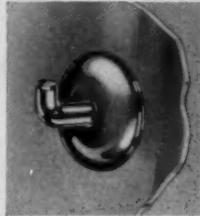
As a standard removable fastener or a blind rivet

A quarter-turn locks, unlocks. Load-carrying steel arms lock securely, don't loosen under vibration. One-piece (no receptacle) simplifies blind fastening.



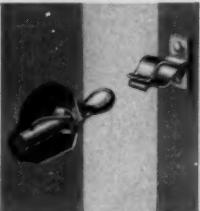
As a roller axle

Now used on range drawers, kitchen cabinets, file cabinets, desks. Cuts installation costs, saves time. Designed to suit. Available with or without roller.



As cup hooks

High-strength polystyrene or chrome-plated die cast zinc. Inexpensive, sturdy and good-looking. Simply and quickly installed with a twist of the wrist.



As a cabinet door strike

Millions in use on kitchen cabinets, automatic dishwashers, etc. Standard strikes available from stock, or custom designed for special contour requirements.



As a plastic shelf support

... with the heart of steel for extra strength. Millions now used by all major refrigerator manufacturers. Complete flexibility of head design.

What is your application for SPRING-LOCK?

Send us your application inquiries. Our engineers will answer you specifically and promptly. Or, write today for the Simmons Catalog. SPRING-LOCK samples are available upon request.

SIMMONS FASTENER CORPORATION

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QUICK-LOCK

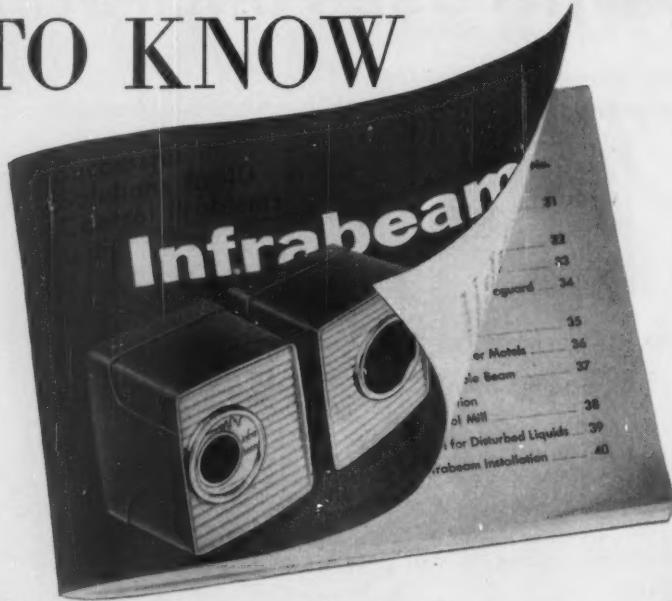
• SPRING-LOCK

• ROTO-LOCK

LINK-LOCK

• DUAL-LOCK

NEW! FACTS YOU NEED TO KNOW



about photoelectric controls

Here, in a compact, idea-sparking handbook, is proof that photoelectric controls *can* work — reliably, without fussy engineering, and at long range. They're being used profitably *now*, for machine control, door automation, area surveillance, conveyor control, materials handling, remote control of liquid levels, and countless other applications.

Forty case histories show you graphically how others use Infrabeam to solve tough problems like these:

- Protecting a 1,000 foot fence
- Checking the level of violently rippling liquids
- Preventing damage to machines and operators
- Avoiding wasteful process operation
- Automatically controlling a distribution conveyor

Infrabeam is a totally new type of photoelectric control. It uses *infrared* radiation, *not* visible light, for superior reliability at long range and under difficult light conditions. The beam is *modulated*, to prevent actuation by strong sunlight or incandescent lamps.

It's easy to install and use, too — reliably solves control problems where limit switches, pilot relays and other electromechanical devices are unsatisfactory.

Get the facts. Write for your free copy of "Successful Solutions to 40 Control Problems".

ELECTRONICS DIVISION
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NEW PARTS AND MATERIALS

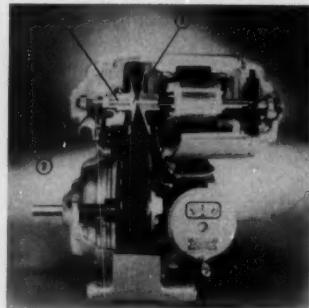
friction loading, assuring smooth, stable adjustment and eliminating backlash. Friction between aluminum case and nylon worm gear locks the wiper in place after each adjustment and holds it fast against shock or vibration. Potentiometer Div., Daystrom, Inc., Archbald, Pa.

Circle 680 on Page 19

Adjustable-Speed Drive

requires no lubrication

All bearings, both sealed and shielded, are factory lubricated and require no lubrication in new adjustable-speed drive. Shaft surfaces are impregnated with a tough, wear-resistant material which eliminates need for lubrication, and nonmetallic bushings are also wear-resistant. Since lubrication maintenance is un-



necessary, drive can be installed in any location. It is available in $1/4$ to 25 hp size with output speeds from 4660 to 0.4 rpm in speed variations to 10:1. All dripproof, totally enclosed fan-cooled, and explosionproof adjustable-speed models require no lubrication. Dept. B-1, Sterling Electric Motors Inc., 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 681 on Page 19

Air Cylinders

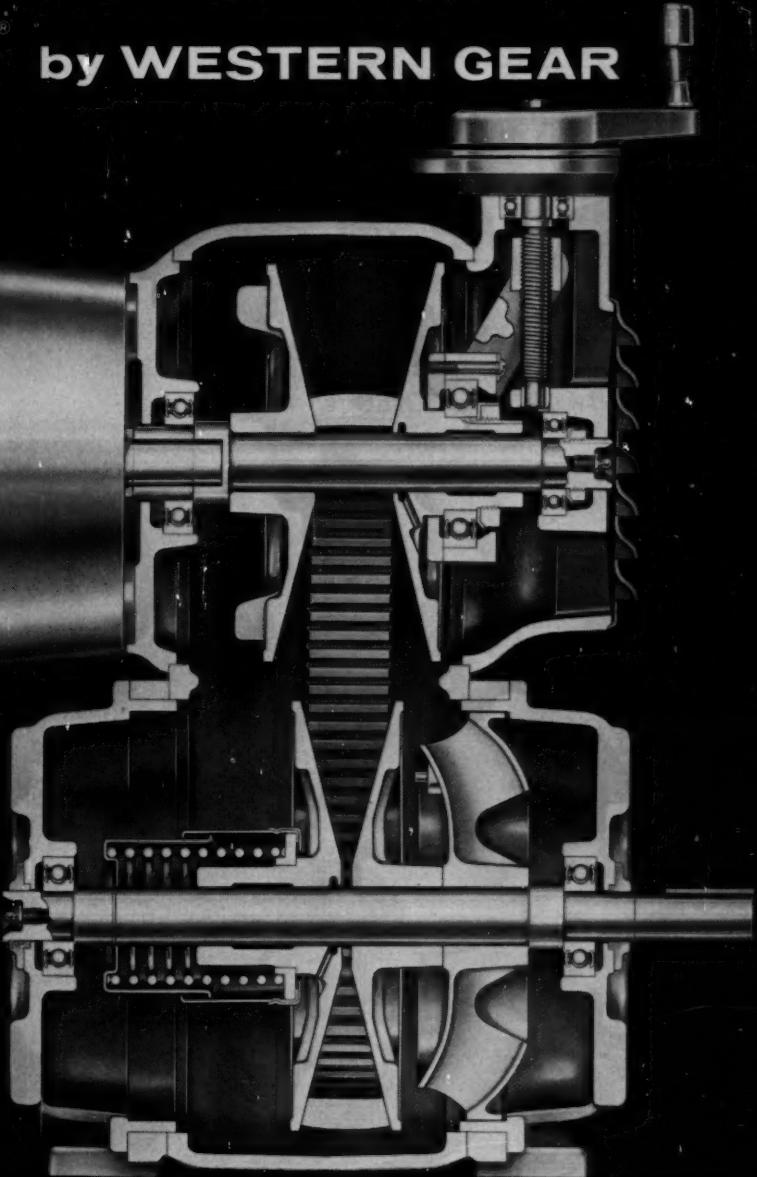
permit adjustment
of stroke lengths

Adjust-O-Stroke design uses a series of $1/16$ -in. spacing washers to position piston on piston rod. Cylinders are manufactured in stock stroke lengths in increments of 1 in. Correct size is obtained by ordering a stock length, then removing front spacing washers and adding a corresponding number of rear spacing

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*the variable
speed-drive
you designed*



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variable speed drives, combining all the best features of variable speed drives, plus Western Gear's own built-in reliability and versatility. Get unequalled performance in the new Vari-Master variable speed drive. You asked for, and Vari-Master delivers ■ unmatched flexibility ■ up-to-the-minute design improvements ■ utmost compactness ■ infinitely adjustable speeds ■ unlimited versatility ■ easy motor replacement ■ 120 basic configurations ■ superb quality. *On the long run... QUALITY COSTS YOU LESS!* For full details, write Western Gear Corporation, Industrial Products Division, P.O. Box 126, Belmont, Calif., for Vari-Master Bulletin 6107F or ask your Western Gear salesman to deliver the 120-page Bulletin 6107.

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OTHER TYPICAL VARI-MASTER ASSEMBLIES



DESIGN FOR SUPERIOR PERFORMANCE

*with Lord
vibration/shock/noise control*



how Lord can help improve performance

High-strength elastomeric mountings and joints are custom designed to control dynamic disturbances, reduce noise transmission, accommodate relative motion . . . thereby upgrading performance, reliability, acceptance. These compact, easy-to-install units resist severe conditions, often outlast metal parts, never need lubrication.

on lift trucks . . .

- Engine mountings isolate engine disturbances.
- Floorboard mountings, seat mountings, steering wheel bushings and accelerator pedal mountings give driver fatigue-free comfort.
- Rear axle springs (lubrication-free pivots) assure smoother ride.
- Axle bumpers and mast bumpers cushion operating shocks.
- Actuating cylinder bushings eliminate binding and lubrication.
- Radio mounting systems protect electronic components.

Lift trucks can be designed for greater operator comfort, lower maintenance requirements and longer component service life.

Lord-engineered vibration control is a proved route to this better performance . . . and to the competitive edge it will give your truck.

Now, while that new model is on the drawing boards, is the time to consider vibration control, the time to talk to a Lord engineer. You will find him knowledgeable on lift trucks, quick to grasp your problem, able to offer authoritative assistance on vibration/shock/noise control.

Lord engineers are ready to help you in your effort to design for superior performance. Contact your nearest Lord Field Engineering Office or the Home Office, Erie, Pennsylvania.

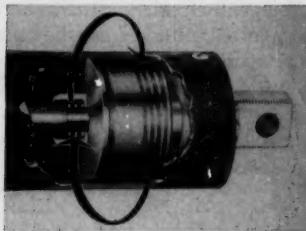


FIELD ENGINEERING OFFICES

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DETROIT, MICH. - Diamond 1-4340
KANSAS CITY, MO. - Westport 1-0138
LOS ANGELES, CAL. - Hollywood 4-7593
NEW YORK, N. Y. (Paramus, N. J.)
- New York City - Bryant 9-8042
Paramus, N. J. - Diamond 3-5333
PHILADELPHIA, PA. - PEnnypack 5-3559
SAN FRANCISCO, CAL. - Exbrook 7-6280
WINTER PARK, FLA. - Midway 7-5501

"In Canada — Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.



washers. Stroke length is thus reduced to fractional requirement without disturbing mounting dimensions. Adjust-O-Stroke is offered on Economair Series R, Provenair Series M and VIH cylinders, and on power machine control unit. Modernair Corp., 400 Prede St., San Leandro, Calif.

Circle 682 on Page 19

Molding-Grade Polypropylene

for use at
high temperatures

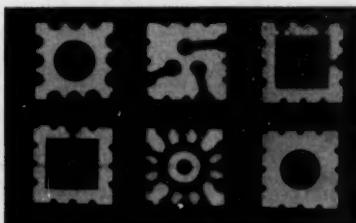
Escon 125 LTHA molding polypropylene is recommended for applications in which molded parts are subjected to repetitive, long-term heat exposure, such as backs for television sets, radio cabinets, under-the-hood automotive parts, lighting fixtures and diffusers, and parts for washing machines, clothes dryers, and dishwashers. Material offers high oxidative stability. Melting point is 335 F, and melt index is 5.5 at 230 F. Enjay Chemical Co., Room 1122, 15 W. 51st St., New York 19, N. Y.

Circle 683 on Page 19

Metallized Ceramic Parts

tiny units can be
hermetically sealed

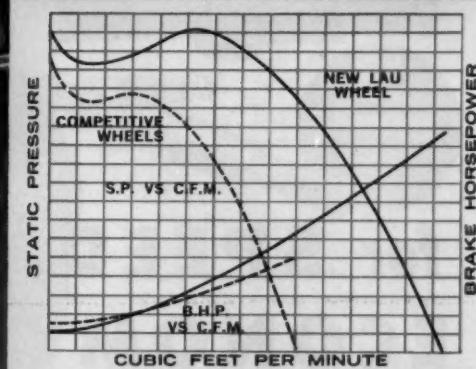
New line of micro-modules with thicknesses from 0.010 in. are 96 per cent alumina, metallized with molybdenum manganese and plating which make parts suitable for soldering or brazing. Parts can be



DO YOU NEED A
**HIGHER EFFICIENCY
SMALL BLOWER
WHEEL?**

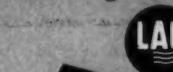


GET
INCREASED
PERFORMANCE
WITH THE NEW
LAU $4\frac{1}{4}$ to $8\frac{1}{2}$
SPUN WHEEL



Lau Engineering has successfully developed a blower wheel that out-performs any wheel of comparable size tested. This powerful, compact unit is specifically designed for installation in room air conditioners but can be used effectively in most appliance applications. Lau "spun" construction contributes greatly to the wheel's structural rigidity and to a very high CFM to WATT ratio.

This new Lau wheel is offered in a customer's choice of aluminum, cold rolled steel or zinc grip and in a range of diameters, blade lengths, bore sizes and back plate designs.



THE LAU BLOWER COMPANY
2027 Home Avenue

Dayton 7, Ohio

Mr. Wm. H. Wentling, Director of Engineering
The Lau Blower Co., 2027 Home Ave., Dayton 7, Ohio

Please send me your engineering data file on the new Lau high performing wheel. We would like to see sample wheel.

Name _____

Position _____

Company Name _____

Address _____

HUCK

fasteners

**for SPEED,
ECONOMY,
DEPENDABILITY**

HUCK gives you MORE than "just a fastener". Huck's foolproof installation tools, convenient power units and versatile fasteners give you uniformity and speed of installation beyond your fondest hopes, even with inexperienced operators. Savings of up to seventy per cent on installed cost have been obtained by many users of Huck fasteners.

There is a HUCK fastener to meet your specific requirements whether they be high tensile or shear strength, blind application, thin sheets, wood-to-metal, broad bearing area, flush installation, high clinch, positive mechanical lock, elevated temperature, corrosion resistance or speed of application. A phone call can save you important production dollars. It costs you nothing to find out.

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HUCK
MANUFACTURING COMPANY

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NEW PARTS AND MATERIALS

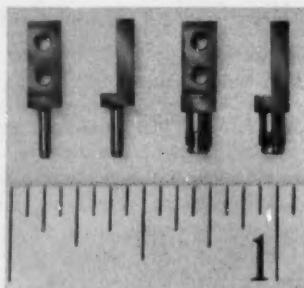
hermetically sealed. Intricate and mechanized circuitry can be applied by screening and other methods. Many configurations, including holes and shapes, can be fabricated. Mitronics Inc., 1290 Central Ave., Hillside, N. J.

Circle 684 on Page 19

Plug and Jack Assembly

for printed-circuit-board applications

Miniature side-mounted plug and jack assembly is suited for printed-circuit-board applications. Both jack and plug measure $\frac{1}{8}$ x $\frac{1}{8}$ in. at maximum cross section. Section with mounting holes projects 0.062 in. above the board. Both plug and



jack are brass per QQ-B-626a, finished in 0.0002-in. silver plate plus 0.00002-in. gold flash. Jack is spring-loaded compression type with slotted key. Spring is beryllium copper per MIL-C-6941, finished in bright alloy plate, cadmium plate plus iridite, or silver plate plus gold flash. Key is brass per QQ-B-626a finished in bright alloy plate or silver plate plus gold flash. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.

Circle 685 on Page 19

Nylon-to-Nylon Belting

for conveyor applications

Rod-type, NB-5 nylon-to-nylon belting for conveying applications utilizes dual nylon sprockets with two equalizing bearing surfaces which engage free-turning, nylon-tipped rods held in alignment by triple link-to-rod construction. The low-friction belting can be used on runs up to 150 ft with a single drive, and no lubrication is required. Operating speeds to 850 fpm with perfect

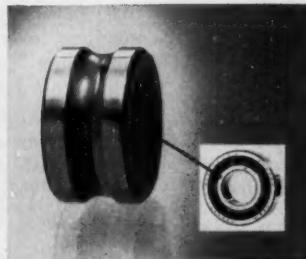
A NEW PRODUCT DEVELOPMENT FROM BARDEN

PERFORMING WELL IN A HOT SPOT



As every parent knows, small boys have an amazing capacity to perform well in heat that would fell the average adult. In much the same way, BarTemp* ball bearings operate effectively up to 575° F., permitting synchros, fans, control motors and other lightly loaded devices to perform at higher temperatures than ever before.

*TRADE MARK



▲ Unretouched photo of inner ring from BarTemp bearing that ran 2727 hours—1010 hours at 500° F. plus an additional 1717 hours at 575° F. Dark band in raceway is lubricant transferred from retainer.

▼ Excerpts from lab and field test results.

Bearing	Tempera-ture	Speed (RPM)	Hours
SR3HX110	500° F. 575° F.	1,200	2727
SR4HX110	338° F.	10,000	2500+
SR3HX110	392° F.	1,200	1240+
SR3BSSX112	500° F.	4,500	1036+
SR2HX110	575° F.	2,500	1628

NEW DESIGN DEVELOPMENTS

Two design innovations made BarTemp possible—a Barden-developed heat treatment for stainless steel used for the bearing rings, and a new retainer that serves as a dry lubricant and a ball separator. The BarTemp retainer, reinforced Teflon compounded with a solid lubricant, is the sole lubrication required. As the bearing rotates, the balls transfer microscopic particles of the lubricant to the raceways.

TEST RESULTS

In tests by more than 20 precision bearing users, BarTemp bearings in synchros, control motors, blowers, pressure switches, tachometer generators and other lightly loaded devices have operated from 1000 to 24,000 RPM and at temperatures from -100° F. to 575° F. Typical life exceeds 1,000 hours.

PROTOTYPES AVAILABLE

Prototype quantities of seven BarTemp sizes from .3125" to .7874" O.D. are immediately available in angular contact types, open or shielded. For further data and detailed test results, ask for BarTemp Data Sheet B-1.

Barden is a major supplier of miniature, instrument, spindle and turbine bearings volume-produced to ABEC 7 tolerances or better for reliability...specify

BAR DEN

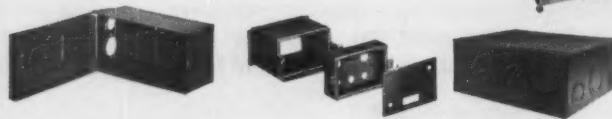


PRECISION BALL BEARINGS

THE BAR DEN CORPORATION, 208 Park Ave., Danbury, Conn. • Pioneer 3-9201
Western Office: 3850 Wilshire Blvd., Los Angeles 5, Calif. • Dunkirk 5-0034

we're
open
for
odd
jobs

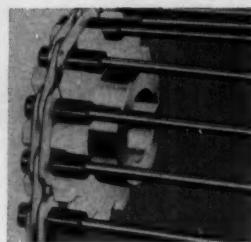
Whatever your wiring problem—Keystone can design and fabricate "odd", custom cabinets to meet your *exact* requirements. Complete engineering and manufacturing facilities assure you of prompt, dependable service on special wiring enclosures in any size, shape or style you need. So, turn your special problems into ready-to-wire solutions with Keystone's experienced Custom Products Division. Just send specifications and a drawing—for a prompt quotation!



KEYSTONE
MANUFACTURING COMPANY
DIVISION OF *Avis* INDUSTRIAL CORPORATION
23332 Sherwood Ave. • Warren, Michigan

Circle 376 on Page 19

NEW PARTS AND MATERIALS



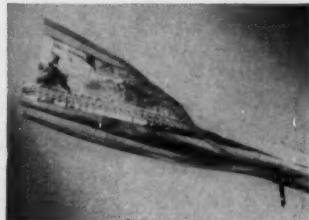
alignment can be attained. Belting is available in stainless steel, steel, and aluminum in a wide range of coatings. *Velten & Pulver Inc.*, 103rd & Ridgeland, Chicago Ridge, Ill.

Circle 686 on Page 19

Zipped Tubing

has shielding of aluminum foil laminated to glass cloth

Type SH shielded Zippertubing incorporates 1-mil aluminum foil laminated to vinyl-impregnated glass cloth to solve transient RF interference problems. Edge of the aluminum shielding has aluminum braid which facilitates grounding and assures positive contact and complete coverage of the entire circumference. Tubing is a pliable conduit, shipped in flat form so it can be stored in a minimum of space. Plastic zipper attached to the vinyl-impregnated, glass-backing material simplifies cable-jacket application, since tubing is placed around the



wires and zipped closed. *Zippertubing Co.*, 13000 S. Broadway, Los Angeles 61, Calif.

Circle 687 on Page 19

Vaneaxial Blower

delivers 68 cfm of air at 1.5 in. static pressure

VAX-3-GN vaneaxial blower operates on 115 v ac, 60 cycles, or 115 v dc, delivering 68 cfm of air at 1.5 in. static pressure. Unit weighs 1 lb, has a diameter of 3 in. and

t²otal retaining ring ideas

to help you cut costs—improve product design and performance

Circolox

the newly designed, precision die-formed retaining ring—available in a variety of materials and finishes—from .040" and up in popular shaft increments.



EXTERNAL TYPE

—for axial installation

Specifically designed for NAS 670 standard grooves. Termed the CS Series, stocked in all popular sizes.



INTERNAL TYPE

—for axial installation

Specifically designed for NAS 669 standard grooves. Termed the CR Series, stocked in all popular sizes.



EXTERNAL TYPE

—for radial installation

Provides unusually large shoulder for small shafts—termed the CE Series, stocked in all popular sizes.



EXTERNAL TYPE

—for radial installation

Provides double the thrust capacity of standard "E" rings (CE) with comparable large shoulder.

SPECIAL RING SHAPES

—engineered to your requirements

Ramsey engineers will be glad to work with you on the design of special ring shapes to meet your individual needs.



STACKED RINGS

—for rapid assembly

All CE Series rings from $\frac{1}{16}$ " to $\frac{3}{4}$ " can be supplied stacked on hardened rods for assembly line operations.



SPECIAL THICKNESSES

—heavier or lighter than standard

Rings heavier or lighter than standard thicknesses can generally be supplied on special order.



SPECIAL MATERIALS AND FINISHES

A wide variety of special materials, finishes and platings are available to meet practically any requirement. Ramsey engineers will help you select the type best suited to your needs.

MATERIAL	FINISH
Spring Steel	Cadmium Plate
Stainless Steel	Parkerized
Phosphor Bronze	Blued Steel
Beryllium Copper	Black Oxide
	Lubrite Finish

Ramsey's special finish technique eliminates burrs and scale for maximum performance. Precision design eliminates bevelling or waviness in the ring. Tapered section design permits maximum conformability. Ring grip is not adversely affected by expansion or contraction within the allowable limits. Together with the complete selection of materials and finishes, Circolox gives you unlimited opportunities to cut costs and improve product design and performance. Circolox rings meet all industry and government standards.

or—you may find the answer in

the unique 360° spiral-wound retaining ring

This exclusive full round retaining ring is mass produced on high speed rollers in a practically unlimited range of sizes. Prototypes can be made without need for tooling. Sizes made from .375" up to .48" and in many varieties, such as single turn, multi-turn, self-locking, resilient take-up, etc. Check these outstanding features:

- Uniform wall allows installation with minimum clearance.
- Two-turn, full-circle design eliminates gaps.
- No special tools needed for installation or removal.
- Special deep groove design withstands greatly increased thrust loads.
- Covered by Government Specification MIL-R-27426.

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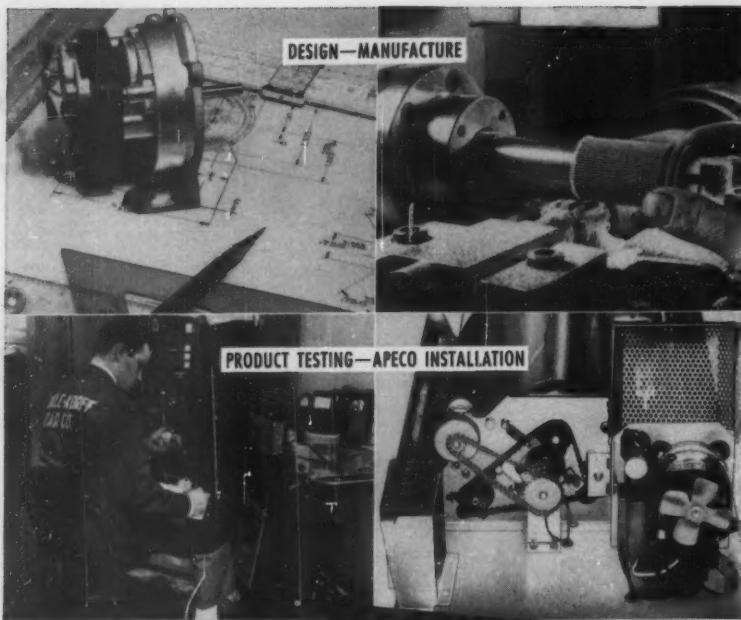
this FREE engineering manual brings you the complete t²otal 2 story!

Contains full descriptions of Circolox and Spirolox Rings with complete design information and specifications. Write TODAY!

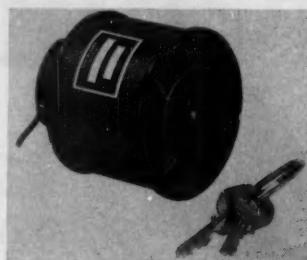
manufactured by

RAMSEY CORPORATION

a subsidiary of **Thompson Ramo Wooldridge Inc.**
Box 513, Dept. B, St. Louis 66, Mo.



NEW PARTS AND MATERIALS



length of $3\frac{1}{4}$ in. Mounting is made by clamping to servo rim at either end of blower. Unit meets pertinent MIL specifications. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio.

Circle 688 on Page 19



HOW MERKLE-KORFF "PERFORMANCE BALANCE" PAYS OFF IN FHP GEARMOTOR DEPENDABILITY

Performance Balance is the perfect mating of Merkle-Korff motor and gearing to your specific application. It prevents money waste and equipment damage through overpowering, and eliminates operating failures due to occasional low voltages and the many hidden hazards of underpowering. Either, or both, the result of "underknowledge" of the drive system by a gearmotor manufacturer.

Merkle-Korff's total understanding based upon 50 years of experience in supplying the right power unit for any given job is available to you. We will, and do, develop and manufacture gearmotors designed to your individual requirements, not only to perform satisfactorily, but to do so at lowest cost. Merkle-Korff service is unique in this respect.

Performance Balance, therefore, is not just a play on words. It is your guarantee of on-the-job performance and dependability. Thousands of cases exist proving the worth of Performance Balancing.

Literature is available. Better still, send us your drawings or product sample so our Applications Engineers can give you a complete evaluation of motor and entire drive system! There is no obligation.

MERKLE-KORFF



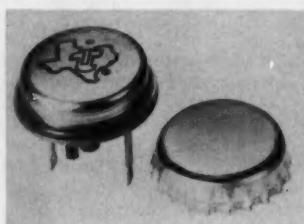
MERKLE-KORFF GEAR CO.

215 NORTH MORGAN STREET • CHICAGO 7, ILLINOIS • MONroe 6-1900

Germanium Power Transistors

have low profile
in TO-36 case

Pancake series of germanium power transistors features 150-w dissipation, low profile in TO-36 case, and 0.5 deg C per w maximum thermal resistance. Transistors are for use in computers, converters, regulators, power supplies, oscillators, servo systems, and electrical transistorized units that require a



power supply. **Semiconductor-Components Div.**, Texas Instruments Inc., P. O. Box 5012, Dallas 22, Tex.

Circle 689 on Page 19

Cable Clamps and Ties

are unaffected by moisture

Lok-Strap adjustable cable clamps and cable ties are available in a material providing complete flexibility from -65 to $+225$ F. They are unaffected by moisture and are durable in applications subject to flexure and vibration. They do not become brittle due to low-temperature exposure, nor do they show any appreciable stretch at their upper-rated service temperature. Straps

**WRITE SPECS
YOU'VE NEVER
WRITTEN BEFORE!**



Wide Operating
Temperature Range



High Spring Retention

Excellent Wear Resistance
and Hardness



Good Corrosion Resistance

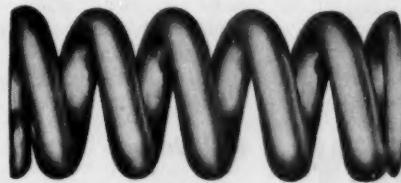


Non-Magnetic



Good Conductivity

BERYLCO Beryllium Copper alloys combine all these properties. By extending the performance possibilities of metal parts, Berylco beryllium copper alloys are opening new areas of design thinking. And you can specify Berylco alloys without fear of complication because they fabricate easily by standard production methods. Some designers are finding that *one* beryllium copper part will do where two parts were formerly required. Factual data on Berylco alloys will show you why the use of strip, rod and casting ingot is increasing so rapidly. Write now for our latest **BERYLCO BERYLLIUM COPPER BULLETIN**. A knowledgeable, experienced technical staff of field men and mill men stand ready to help you develop design possibilities into performance realities.



High Strength



Resistance to Anelastic Behavior

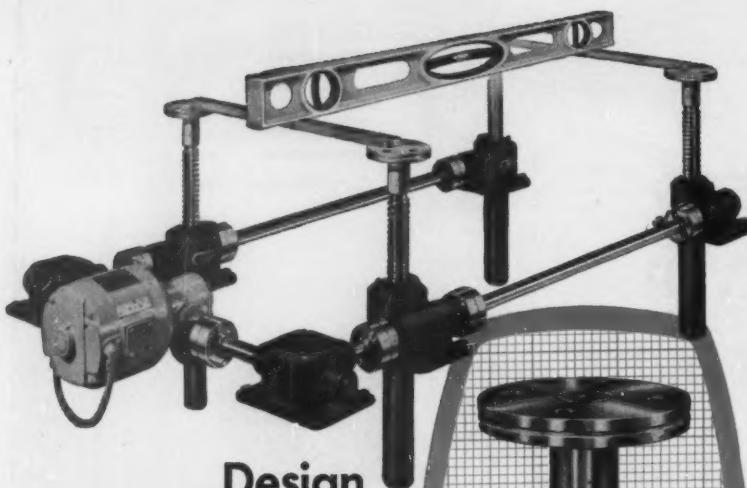


High Fatigue Strength



THE BERYLLIUM CORPORATION

Reading, Pennsylvania



**Design
Uniform lift
into equipment
with
DUFF-NORTON
WORM GEAR
JACKS**

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive



and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66-MD.

DUFF-NORTON COMPANY

Four Gateway Center • Pittsburgh 22, Pa.

COFFING HOIST DIVISION • Pittsburgh, Pa.

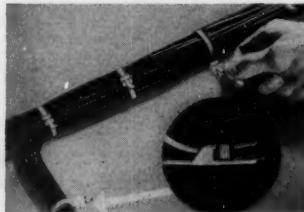
DUFF-NORTON JACKS

Ratchet • Screw
Hydraulic • Worm Gear



COFFING HOISTS

Ratchet Lever • Air
Hand Chain • Electric



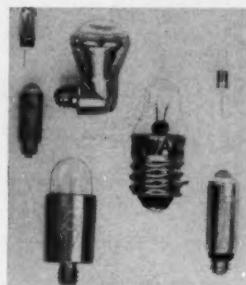
can be opened, closed, and re-adjusted repeatedly without damage, without special tools. Miniature, quick-release tab holds band of the clamp or tie securely and tightly around wires, but opens instantly when fingertip pressure is applied. Tab allows adjustment to accommodate wire harnesses from $\frac{1}{8}$ to 2 in. diam. Dept. MD-1, Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill.

Circle 690 on Page 19

Miniature Lamps

in 14 different styles

Miniature lamps, originally developed for use in medical diagnostic instruments, have uses in many industrial and technical applications. Fourteen different styles are available from stock, and special styles are made for specific needs. Lamps are brilliant and durable, with projected beams of light free from fila-



ment shadows or other aberrations. Welch Allyn Inc., 170 Jordan Rd., Skaneateles Falls, N. Y.

Circle 691 on Page 19

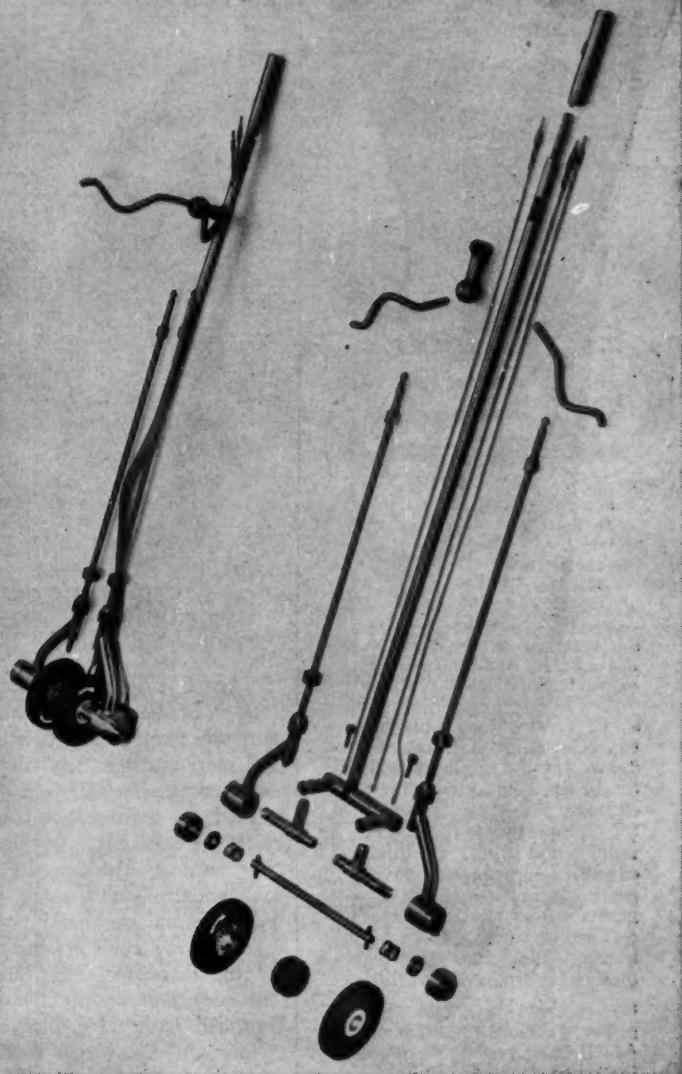
Ball Valves

incorporate two
Teflon seats

Bar stock, bidirectional Flo-Ball valves are available in six sizes from $\frac{1}{4}$ to 2 in. diam. Valves have two Teflon seats that seal the flow in both directions. Rated at 600 psi

HERE'S
HOW STILL
ANOTHER
MANUFACTURER
JOINS
STAINLESS
STEEL
TUBING:

*He uses
Handy & Harman's
BRAZE 630*



He's one of many manufacturers and fabricators who have found—to their lasting satisfaction—that Handy & Harman silver alloy brazing is the final answer to stainless steel joining problems.

Super-Donic Manufacturing Company, Atlanta, Georgia, manufactures "Dual Arm Transmissions" for the dental industry. Most everybody has—at one time or another—seen and/or felt this unit in operation.

It is fabricated of small diameter 304 and 316 stainless steel tubing and, in its assembled form, consists of some 17 separate brazed joints. Joints must be strong, corrosion resistant and neat-appearing.

FOR A GOOD START:
BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits . . . includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



Your No. 1 Source of Supply and Authority on Brazing Alloys

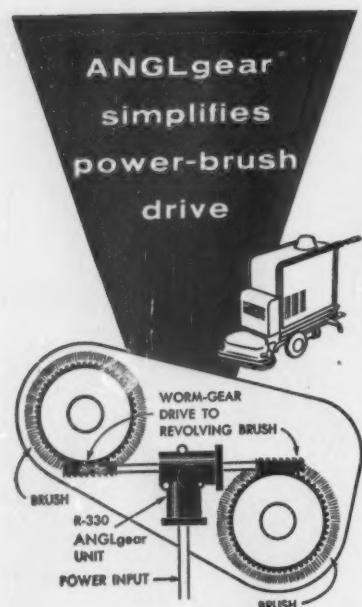


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Cutaway shows use of 1 hp ANGLgear in brush head of LAWLRmatic 26 in. electric floor scrubber. Company employs ANGLgear in several of its other models as well.

S. C. Lawlor Co., Chicago, Ill., selected ANGLgear 90° drives for the scrubber/buffer heads of its power floor cleaners for these reasons: (1) compactness—helps cut weight and bulk; (2) high capacity—hardened bevel gears transmit more hp; (3) permanent lubrication—saves on maintenance; (4) sealed housing—eliminates possible fouling by wax or detergents.

If you have a similar 90° power take-off requirement, ANGLgear probably offers the simplest, most economical solution. Available immediately from stock, these standardized right-angle drives are easily incorporated in your power transmission systems* because of their compactness and universal mounting feature.

*Design templates free on request

You can specify ANGLgear in 1/2, 1, 2 1/4 and 5 hp ratings with 1:1 or 2:1 gearing and 2 or 3-way shafting. Send for Catalog 1A-60 or contact our local distributor.



AIRBORNE
Engineered Equipment for Aircraft and Industry
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 382 on Page 19

266

NEW PARTS AND MATERIALS



water, oil, or gas, valves are available with NPT and AND threaded ends in carbon steel, 303 and 316 stainless steel, and brass. Hydrodynamics Inc., 5 Lawrence St., Bloomfield, N. J.

Circle 692 on Page 19

Aluminum-Foil Marker

on quick-release comb-type dispenser

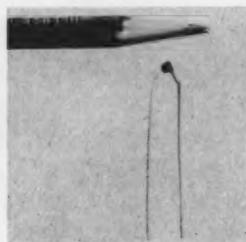
Tabber is a new comb-shaped dispenser for serially-numbered, pressure-sensitive, anodized aluminum-foil marker strips. Any combination of letters and/or digits can be furnished, in consecutive order, for quick removal and application to any surface. Markers are individual anodized tabs, each debossed with a serial number in proper sequence, and each an integral part of the dispenser. Tabs are pre-cut for easy detachment. Markers are installed with no drilling, tapping, screws, or pins. North Shore Nameplate Div., Anodyne Inc., 1270 N.W. 165th St., North Miami Beach 69, Fla.

Circle 693 on Page 19

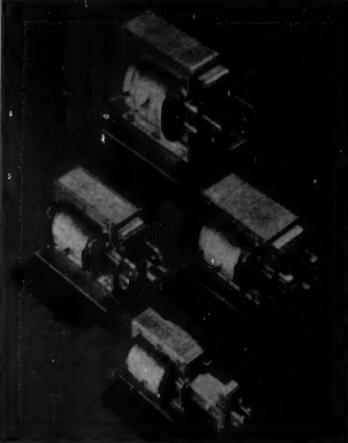
Ceramic Capacitors

subminiature units have rectangular shape

Wee Con dipped phenolic-coated, plate ceramic capacitors offer subminiature size and rectangular shape for use in printed-circuit boards.



NOW! DORMEYER PRESENTS
"AMERICA'S FINEST SOLENOID LINE"



here it is—completely new—completely redesigned—the

DORMEYER SUPER-T-LINE

Check these new and improved features

- Heavier, Sturdier Mounting Brackets
- Extra Heavy, Well Supported Plunger
- High Seating Pull without excessive AC Hum
- High Dielectric Bakelite Bobbin
- Stainless Steel, Non-Rusting, Anti-Residual Spring
- Larger Contact Area between Co-acting Members for Longer Life
- Stronger, Heavy Gauge, Pull-Bar
- Moisture Resistant Coil
- Moisture Proofed or Epoxy Resin Encapsulated Coils available for High Humidity Conditions
- Design provides for Maximum Work without Power Drop-Off

More rugged, with greater designed-in and built-in dependability, the new Super-T deserves to be called "America's Finest Solenoid Line". Write for Catalog today!

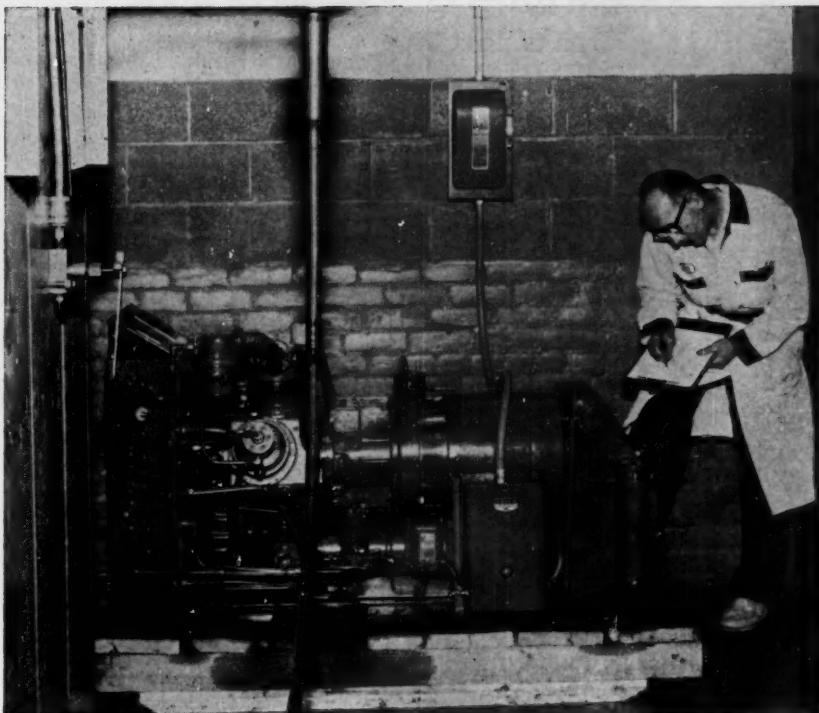


DORMEYER INDUSTRIES
FACTORIES IN CHICAGO AND KENTLAND, INDIANA

Also Builders of Special Coils and Transformers

3634 Milwaukee Avenue • Chicago 41, Illinois

Circle 383 on Page 19



This compact compressor supplies 15 CFM at 5000 psi in a high pressure hose testing facility. Similar machines are available for pressures up to 6000 psi, and volumes up to 80 CFM.

A COMPACT COMPRESSOR FOR HIGH PRESSURE AIR—UP TO 6000 PSI

Joy High Pressure Compressors are easily portable, highly reliable sources for high pressure air for testing. Originally developed for military jet aircraft and guided missile programs, Joy Compressors in pressure ranges up to 6000 psi are field proven for reliability and durability. Currently, they are being used to test high pressure equipment, such as hose, valves, and fittings in numerous Research and Development installations.

These high pressure compressors are compact, multi-stage, V-type machines which are designed for continuous operation. They can be supplied for either electric or gasoline motor drive, and can be skid-mounted or equipped with wheels for complete portability.

If you have testing facilities which require extremely high pressure air, it will pay you to get complete details about the Joy machines. Write for Bulletin 1014-64B.



AIR MOVING EQUIPMENT FOR ALL INDUSTRY



Dust Collectors

Reciprocating & Dynamic Compressors

Fans and Blowers

JOY

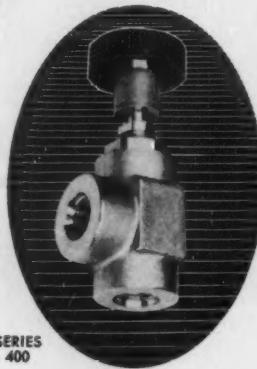
Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company
(Canada) Limited, Galt, Ontario

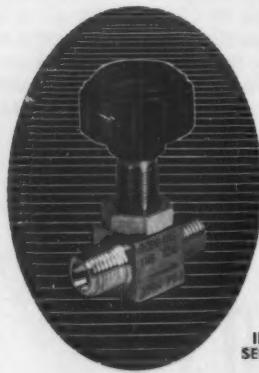
3 UNUSUAL VALVES BY ROBBINS

High Pressure

Slow Opening . . . Excellent Throttling
Up to 12000 PSI Operating Pressure
Rugged . . . Dependable
Pressure Balanced
Stainless Steel Throughout
Unique & Positive Sealing
Self Lubricating
Finger Tip Operating & Shutoff Torque
Both Liquid & Gas Service
Panel Mount in 1 Minute
Service Completely from Panel Front



PRECISION MADE FOR PERFORMANCE!



Instrument

Absolute Bubble-tight Shut-off
Low Torque . . . Finger Tip Control
Fine Metering Characteristics
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High Safety Factor
Male or Female Ports
As Light as .31 Lbs.
Brass or Stainless Steel
Hi-Vacuum to 3500 PSI
For Air-Nitrogen-Helium-Fuels-Hydraulic Oils-Water

DESIGNED TO SAVE YOU MONEY!

Three-Port Hi-Vacuum to 6000 PSI

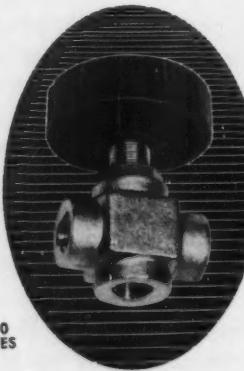
Versatile . . . May be used as a three-port valve with two ports in common, as a globe valve or as an angle valve. A relief valve, pressure gauge, or other device may also be installed in third port.

Simplifies Stocking Problems Stock 1, Serve Many!



When Costs of Replacement and Downtime Are Important . . .
Specify ROBBINS!

T180
SERIES



ALL ROBBINS VALVES FEATURE 4 TO 1 BURST SAFETY FACTOR

Write TODAY for 16-page illustrated brochure in color



3817 S. Santa Fe Ave.
Los Angeles 58, California
Ludlow 9-5221

NEW PARTS AND MATERIALS

They are available in six sizes from 0.150 x 0.150 x 0.100 in. thick to 0.600 x 0.500 x 0.150 in. thick. Capacitance range is 10 pf to 0.036 mf, and working voltage is 200 v dc. Operating temperature is 85 C. Erie Resistor Corp., 644 W. 12th St., Erie, Pa.

Circle 694 on Page 19

Slip-Ring Assembly

accommodates from 15 to 30 rings

Standardized packaged slip-ring assembly is available for application to instrumentation circuits. Single size accommodates from 15 to 30 rings. Current capacity is 2 amp,



250 ac, 60 cycle. Maximum shaft diam is 1 1/4 in. Assembly as designed assures low noise level with aircraft reliability built in. Cover, when closed, assures a dirt and splashproof unit. Superior Carbon Products Inc., 9115 George Ave., Cleveland 5, Ohio.

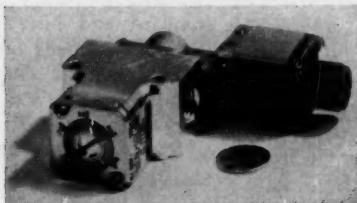
Circle 695 on Page 19

Pressure Switches

provide indication over 15 to 2000 psid range

Deltadyne pressure and differential-pressure switches are small, lightweight devices which open or close an electrical circuit when pressure, differential pressure, or flow becomes too high or too low. Switches provide reliable indication over the range from 15 to 200 psid. Within the pressure range of a given switch, actuation pressure can be altered by turning a direct-reading dial. Units withstand system pressures or overpressures to 5000 psi. They are suitable for use in industrial and airborne systems. They can be used in all types of fluid lines including pneumatic sys-

NEW PARTS AND MATERIALS



tems and compressed gas lines, hydraulic systems, process streams, and other types of fluid systems where an alarm device is required. Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 696 on Page 19

Wound-Rotor Motors

in small-frame sizes

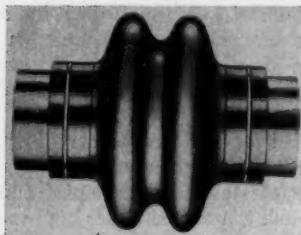
Wound-rotor motors are now available in frame sizes from 182 through 326-U. High starting torque can be applied in a slow-speed step, with full operating speed being reached through a series of steps. Motors are available in all standard horsepower ratings from $\frac{1}{2}$ through 40 hp, plus ten intermediate ratings in this range. All motors have lightweight, heat-dissipating, aluminum-alloy frames. Mounting can be horizontal, ceiling, or side-wall. Reuland Electric Co., Alhambra, Calif.

Circle 697 on Page 19

Universal Joints

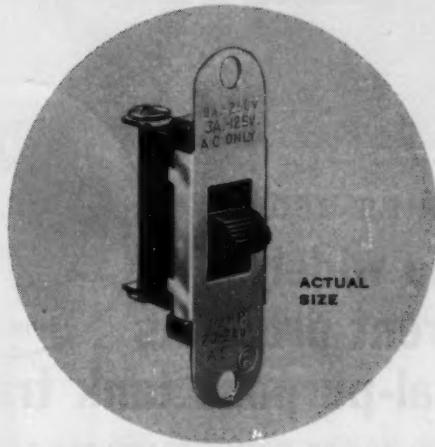
have oil-resistant neoprene covers

Booted universal joints are available for severe service applications. Joints are fitted with oil-resistant neoprene covers which allow them to be prepakced with grease. Cover or boot is held firmly in place by snap wires and can be removed or replaced quickly and easily. Boot allows operation through a full 40-deg working angle. Line incor-



April 13, 1961

NEW SLIDE SWITCH



PLANNED PERFECTION
RUGGED • COMPACT
DEPENDABLE

Circle F announces a new, high reliability slide switch. A product of advanced engineering techniques, this new switch features silver alloy contacts and silver plated rockers, with the entire mechanism enclosed in a dust free, Hi-Impact thermosetting plastic case

Slow make — Slow break precision operation
Specially designed non-welding contacts

This built-in ruggedness provides the long-lasting dependable service so typical of Circle F products

The new Switch — SPST — is available with screw terminals or with lugs designed for both soldering and push-on tabs

It offers 2 hole mounting • 10 amp 250V A-C — 15 amp 125V A-C
• 3 amp 250V A-C — 6 amp 125V A-C

Special ratings on request



CIRCLE F MFG. CO.
TRENTON 4, NEW JERSEY

Circle 386 on Page 19

269

ROPER PUMPS

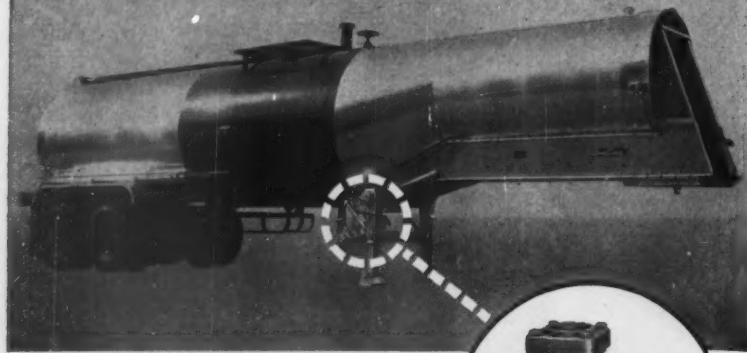


Photo courtesy Great Dane Trailers, Inc.

SERIES 3600

**handle widely
different products
in dual-purpose tank trailers**



Series 3600

CAPACITY: 40-300 GPM • PRESSURES TO 100 PSI

A fleet of dual-product trailers built by Great Dane Trailers, Inc., Savannah, Ga., hauls tall oil, a highly viscous resin by-product, one way and returns with low viscosity gasoline. Roper Series 3600 MAHBRV #4 tank truck pumps were installed on these trailers because of this necessity of handling widely different products. Each pump is directly connected to the tank trailer and to a discharge pipe which permits controlled unloading from either side of the trailer. Each pump is equipped with a relief valve. Series 3600 pumps are available in high- or low-drive models for clockwise or counter-clockwise rotation. They can be side frame or cradle mounted on right or left side.

FOR DOUBLE-DUTY SERVICE

- **BEARINGS:** service-free high-lead bronze, lubricated and cooled through oil grooves by flow of liquid through pump.
- **OUTBOARD BEARING:** heavy-duty ball bearing diverts drive and thrust loads from pumping gears and inner bearings.
- **GEARS:** two equal-sized, hardened alloy iron, helical-type gears with accurately machined special tooth forms reduce friction, eliminate vibration.
- **PACKED BOX OR MECHANICAL SEAL:** extra deep packing box easily repacked with split ring packing and split gland without disconnecting drive or piping. Mechanical seal (3605) is self-adjusting with precision-lapped mating surfaces for positive sealing and long life.

*For information about your specific pump needs
contact your nearest Roper dealer
Send for "How to Solve Pumping Problems" booklet*



**Dependable pumps
since 1857
COMMERCE, GEORGIA**

NEW PARTS AND MATERIALS

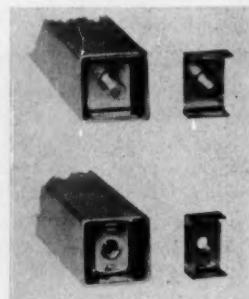
porates both standard and heavy-duty types. Boot OD depends on joint size, ranging from $1\frac{1}{4}$ to $5\frac{1}{2}$ in. Lovejoy Flexible Coupling Co., 4882 W. Lake St., Chicago 44, Ill.

Circle 698 on Page 19

Tubular Inserts

for use in round, square, or rectangular steel tubing

New tubing inserts are two-piece welded parts for inserting in round, square, or rectangular steel tubing for use in products in which tubular sections are integral parts. Inserts for round tubing are available



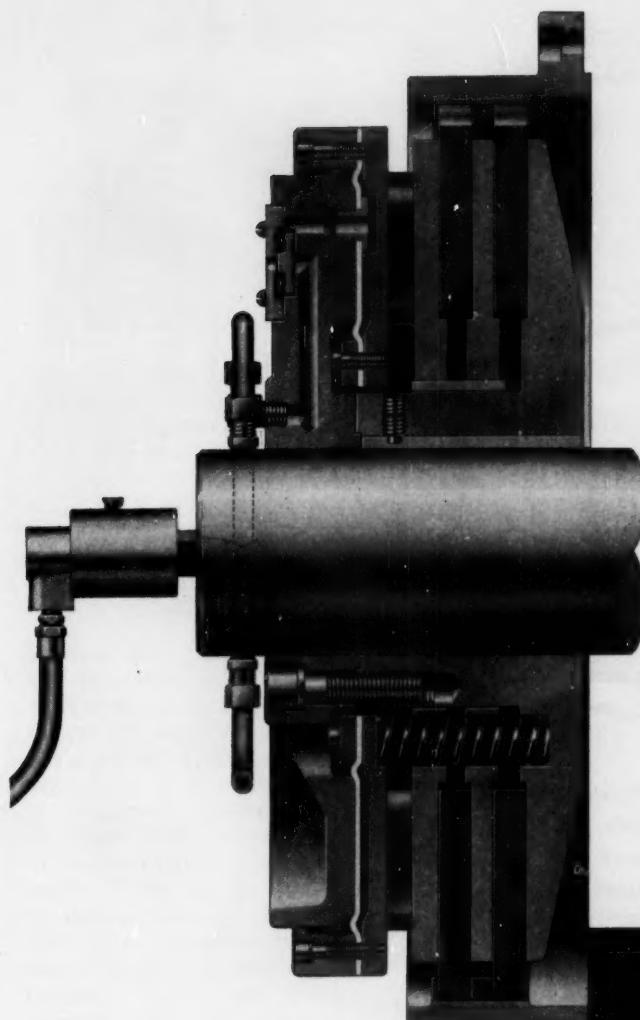
for diameters from 1 to $1\frac{1}{2}$ in., with internal or external threads. For square and rectangular tubing, sizes range from $\frac{7}{8}$ to $1\frac{1}{2}$ in. wide. Stamping, with nut or screw already attached, is inserted in the end of the tubing and spot welded in place. At the present time, inserts are available in 10,000-piece ordering quantities for specific applications. Ohio Nut & Bolt Co., 50 First Ave., Berea, Ohio.

Circle 699 on Page 19

Proximity Switch

is unaffected by dirt, moisture, or oil

Bulletin 1500 general-purpose proximity limit switch is highly sensitive to both ferrous and nonferrous metals. Small pickup $1\frac{1}{8} \times 1\frac{1}{8} \times 4\frac{1}{4}$ -in. size, is unaffected by dirt, moisture, or oil that collects on it, and does not attract metal chips. Proximity switches are applied where limit-switch operation is called for, but environmental or operation requirements prohibit the use of standard mechanical units. Switch is actuated under high speed, by delicate materials, by rough sur-



1. Quickest acting, most responsive air clutch available!
2. Finger tip control!
3. Built-in quick release valves! (Optional)
4. Requires minimum volume of air!
5. No adjustment necessary!
6. Internally ventilated—cooler operation!
7. Operates at air pressures up to 140 psi!
8. Most compact!
9. Interchanges with and can be used to replace Dodge or other mechanical clutches in existing installations.
10. Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.

AIR-GRIP

NEWER! BETTER!

DODGE
of Mishawaka, Ind.



CALL THE TRANSMISSIONEER
—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneers" in the white pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

This air clutch, engineered to modern needs, provides maximum torque capacity in minimum space. Its operation requires less air, resulting in amazing sensitivity. It gives the operator split-second control—from "inching" to full engagement. Quick-release valves are built into the clutch itself, as optional equipment, for instant disengagement where such service is required.

The unique design of Air-Grip places the air seal disc at the end *farthest* from the pressure plates, which generate the heat inherent in clutch action. This combined with automatic internal ventilation, insures cooler operation and longer life under severest service. Call your local Dodge Distributor, or write for Bulletin.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

Is This Job for You?

BACKGROUND—Recent degree in mechanical or electrical engineering. About three years of design-engineering experience.

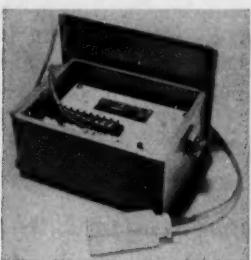
ABILITIES—Able to evaluate technical information on design techniques, new machines, components. Provable ability to write clearly and accurately. Should work well with people, have initiative and imagination, demonstrate creative as well as practical ability.

ENVIRONMENT—Cleveland, Ohio, with some out-of-town travel. As assistant editor on MD's staff of 21 engineer-editors. In Penton Publishing Company, a growth company, with 5 magazines and some 60 editors.

COMPENSATIONS—Salary comparable to that in industry. Chance to grow within the company. Unusual opportunity to broaden education, experience, and contacts. Stimulating work.

* * *

If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, **MACHINE DESIGN**, Penton Building, Cleveland 13, Ohio.



faces, submerged in fluids, through barriers, and in contaminated areas. **Electronic Signals Inc., P. O. Box 3811, Cleveland 10, Ohio.**

Circle 700 on Page 19

Neoprene Tubing

has Teflon lining in $\frac{1}{8}$ to 1-in. ID sizes

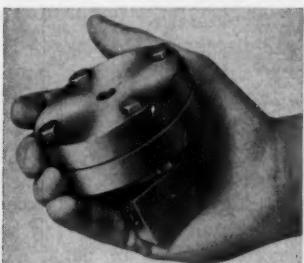
Physical and chemical properties and advantages of Teflon tubing, and thermal protection, scuff, weather, and oil resistance of neoprene are combined in Teflon-lined rubber tubing. It is available for use in a variety of applications where protection to the Teflon is required to prevent kinking or collapsing in service. Teflon liner is available in $\frac{1}{8}$ through 1-in. ID sizes covered with $\frac{1}{8}$ -in. neoprene rubber, or other elastomers, in lengths to meet customer specifications. Neoprene covering withstands continuous service temperature of 200 F for several months without cracking. **Pennsylvania Fluorocarbon Co. Inc., 1115 N. 38th St., Philadelphia 4, Pa.**

Circle 701 on Page 19

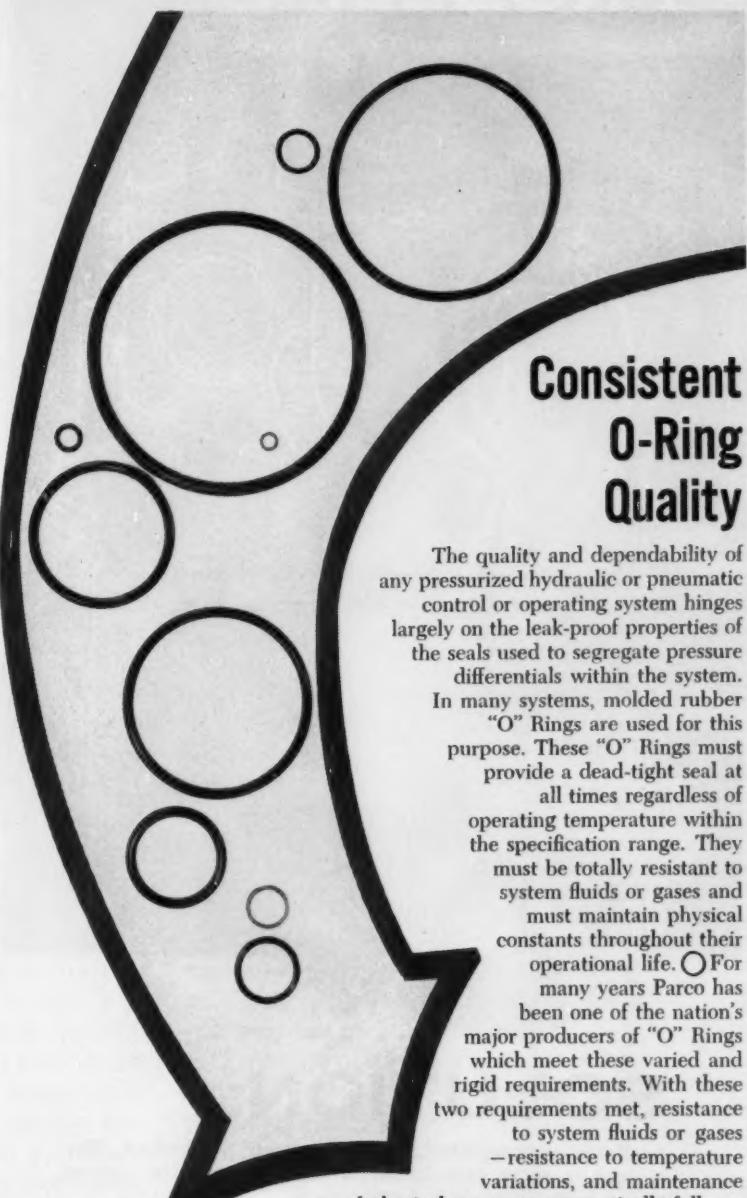
Air-Operated Valves

for pressures to 5000 psi

Compact, lightweight air operator is available for on-off use with $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, and 9/16-in. tubing valves. Built for pressures to 5000 psi, air-operated valves are available in



PARCO PROBLEM PROBERS



Consistent O-Ring Quality

The quality and dependability of any pressurized hydraulic or pneumatic control or operating system hinges largely on the leak-proof properties of the seals used to segregate pressure differentials within the system.

In many systems, molded rubber "O" Rings are used for this purpose. These "O" Rings must provide a dead-tight seal at all times regardless of operating temperature within the specification range. They must be totally resistant to system fluids or gases and must maintain physical constants throughout their operational life.

For many years Parco has been one of the nation's major producers of "O" Rings which meet these varied and rigid requirements. With these two requirements met, resistance to system fluids or gases

—resistance to temperature variations, and maintenance

of physical constants automatically follows. These features add up to the consistent high quality and leak-proof properties which have made Parco "O" Rings a synonym for failure-free operation.

Send for
your latest
Parco Slide Rule



Plastic and Rubber Products Company
2100 Hyde Park Blvd. • Los Angeles 47, Calif.
Please send the Parco O-Ring Data Chart to:

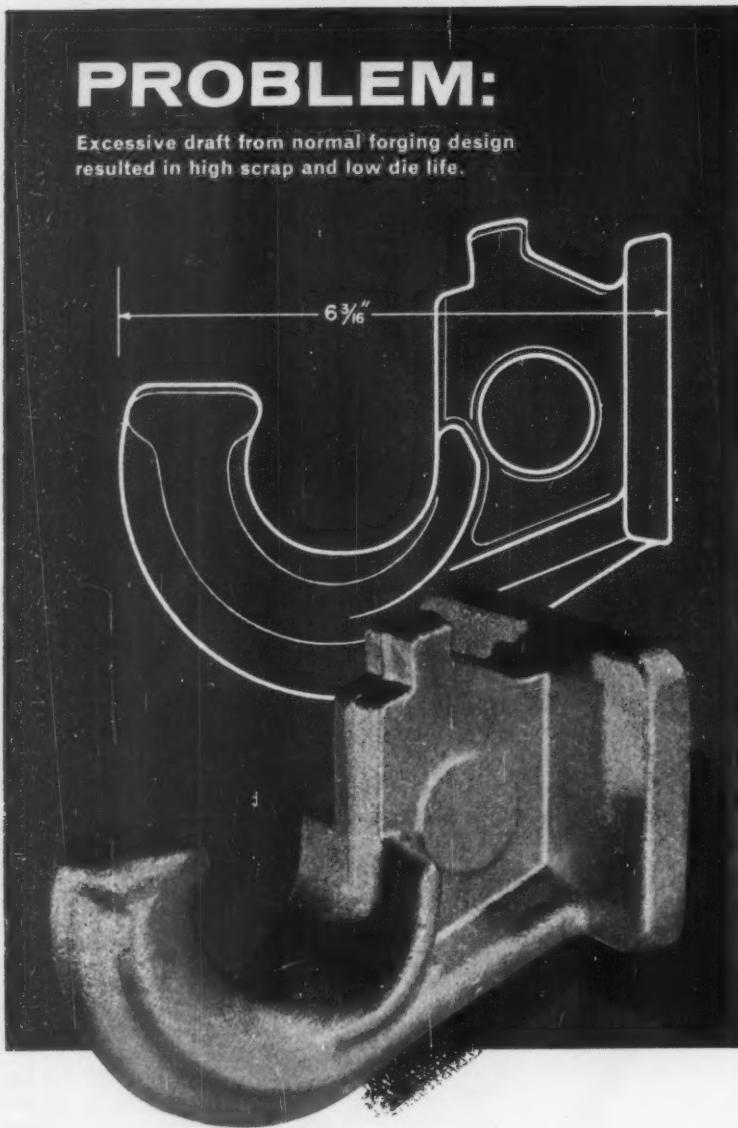
NAME _____

COMPANY _____

BUSINESS ADDRESS _____

CITY _____

ZONE _____ STATE _____



SOLUTION:

AmForge recommended their "no draft" technique. The savings in scrap plus increased die life made the forging design both practical and economical.

Because the head was flat, without draft, the customer was not only given a reasonably priced forging, but was saved machining costs. A further bonus was better strength of the head due to improved grain flow.

If you have a similar problem, consult AmForge. Write for our new brochure and the name of your nearby AmForge sales engineer.

Remember: your problems . . . our challenge!



WHEN IT'S A VITAL PART, DESIGN IT TO BE



a division of American Brake Shoe Company, 1220 West 119th Street, Chicago 43, Illinois. Two plants in Chicago, one in Azusa, California

NEW PARTS AND MATERIALS

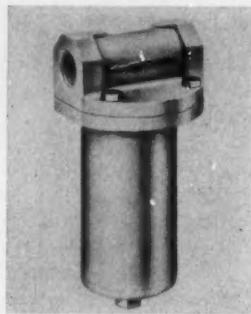
both air-to-open and air-to-close designs. Principal uses are in systems requiring remote on-off operation and in relief-valve systems. Autoclave Engineers Inc., 2945 W. 22nd St., Erie, Pa.

Circle 702 on Page 19

Corrosion-Resistant Filter

has sintered-bronze, shockproof elements

Poro-Pac filters provide complete micronic filtration systems removing contaminants to 5 microns from all liquids and gases. Units have corrosion-resistant brass cases and porous-metal, sintered-bronze, ductile shockproof elements that are



easily cleaned and require no replacement. Operating temperature range is -400 to +900 F. All cases are rated at 250 psi and are completely sealed with O-rings. Pacific Sintered Metals Co., 8333 Hindry Ave., Los Angeles 45, Calif.

Circle 703 on Page 19

Perforated Nylon Strapping

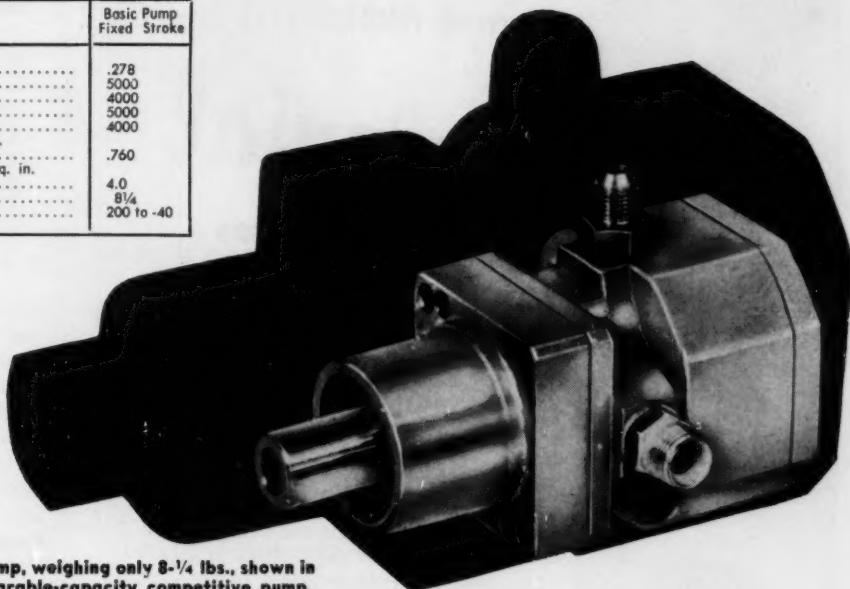
in widths from 0.160 to 0.625 in.

Complete line of perforated nylon strapping now includes widths from 0.160 to 0.625 in. and thicknesses from 0.030 to 0.070 in., in various hole sizes and spacings or nonperforated. Strapping is available in black or natural nylon in 25 or 50-ft roll-dispensing packages. New ratchet buckle provides a nonslip, permanent fastener for tight bundles of cables, wires, tubing. New stud button locks both ends of strapping when pushed through the matching perforations. Two types of mounting tabs which fasten with one screw to wall or panel either

new LUCAS-ROTA~~X~~ industrial HYDRAULIC PUMPS AND MOTORS

offer the most advanced compact design

PUMP DETAIL	Basic Pump Fixed Stroke
Fluid displacement (cub. ins./rev.)	.278
Nominal working pressure (peak) (lb. per sq. in.) (continuous)	5000
Nominal speed (peak) (r.p.m.) (continuous)	4000
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	5000
Max. Torque (lb./ft.) per 1,000 lb. per sq. in. fluid pressure differential	4000
Weight (lb.) Basic Pump	.760
Operating temperature, ° F	4.0 8½ 200 to -40



LUCAS-ROTA~~X~~ IA4 pump, weighing only 8-1/4 lbs., shown in comparison with comparable-capacity competitive pump.

If you are interested in industrial hydraulic pumps or motors in the 1.5 to 108 g.p.m. range at pressures to 5000 p.s.i., you'll find more good design features in Lucas-Rotax pumps and motors than in any other quality line.

Lucas-Rotax industrial hydraulic pumps and motors are smaller and lighter than conventional units with low noise level in spite of high operating speeds. They offer fast response rate in pressure compensation and the low and medium

capacity units can be operated from 2-pole motors to reduce the cost of the prime mover.

Pumps are available as variable volume, variable volume pressure compensated, overcentre cam (reversible) or fixed volume. Motors can be supplied in variable or fixed volume. Both pumps and motors deliver high performance with minimum maintenance. Available in quantity from domestic stock—call or write for technical data.

a product of creative engineering by

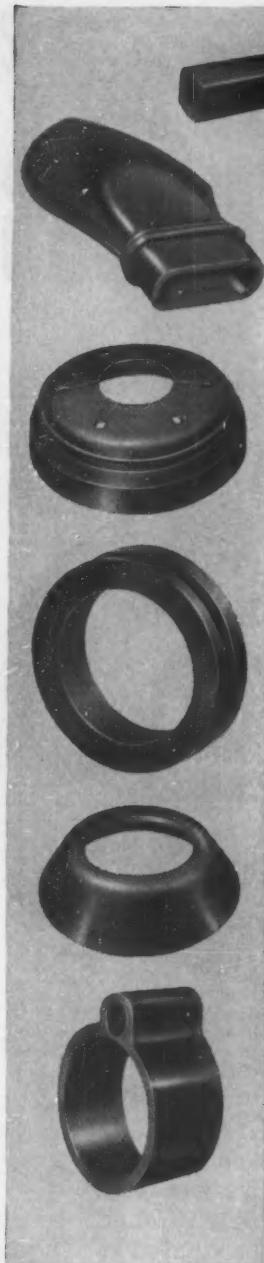
For further information contact
U.S. Representative
JULIUS KENDALL,
Kenall Corporation
320 Washington Street
Brookline 47, Mass.
Longwood 6-0378

LUCAS-ROTA~~X~~

A member of the Lucas organization with
OFFICES AND SERVICE DEPOTS
THROUGHOUT NORTH AMERICA

BOSTON • NEW YORK • CHICAGO • LOS ANGELES • HOU~~STON~~TON • SAN FRANCISCO • CLEVELAND • JACKSONVILLE
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Custom RUBBER COMPOUNDING and MOLDING by
Colonial
assures

► EXPERT COMPOUNDING
► ACCURATE PRODUCTION
► PROMPT DELIVERY of
INDUSTRIAL RUBBER PARTS

Colonial Rubber Company is geared to meet the rubber or silicone rubber parts requirements of product designers and purchasing people alike. We have a long background of industrial rubber experience, plus complete laboratory and production plant facilities to meet your "toughest" requirements economically and dependably.

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Contains complete information on our custom rubber compounding and molding service. If your problem requires immediate attention, send prints and details for prompt analysis or quotation. No obligation.



1557-A

COLONIAL RUBBER CO.

RAVENNA, OHIO

706 OAKWOOD ST.

• AXminster 6-9611

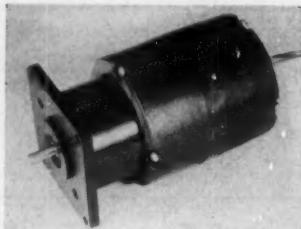
NEW PARTS AND MATERIALS

before or after assembly of wiring are also available. Nylon mounting cradle is designed for premounting before strapped bundles are installed. Strapping and fasteners are suitable for service between -60 and +275 F. Dept. MD-1, Weckesser Co. Inc., 5701 Northwest Highway, Chicago 46, Ill.

Circle 704 on Page 19

Gear Motor

for use in nuclear radiation environment



Model 32U21RP141 motor, which has an integral gearhead, has an input of 110 v, single phase, 60 cycle. Output is 28 oz-in. torque at 20 rpm. Motor, for use in nuclear radiation environments, can be used in continuous-duty service and has an operating life of 500 hr. Electro Products Div., Western Gear Corp., 132 W. Colorado Blvd., Pasadena, Calif.

Circle 705 on Page 19

Switching Transistor

has high switching speeds

PADT-40 transistor is a germanium PNP unit designed for high and medium-speed saturated-logic applications. Average total switching time is 135 nanoseconds and minimum time is 80 nanoseconds. High switching time results from a new technique whereby the collector region is gold doped for lower stored charge. Rugged construction provides high resistance to shock and vibration, high voltage ratings, and high thermal dissipation. It is mounted in the standard TO-18 case, and is interchangeable with mesa and MADT types in existing computers. Semiconductor & Special Purpose Tube Div., Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Circle 706 on Page 19

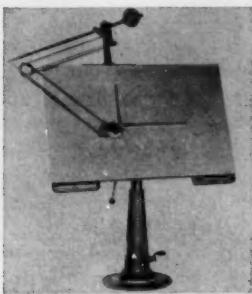
ENGINEERING
DEPARTMENT

EQUIPMENT

Drafting Table

can be rotated
360 deg around base

Nike hydraulic drafting table fits into small space requirements for a fullsize drafting board. Vertical traverse is nearly 2 ft, angle adjustments range from horizontal to vertical, and board can be rotated freely 360 deg around the base. Ability to rotate table permits choice of best lighting. Board can be raised or lowered hydraulically.



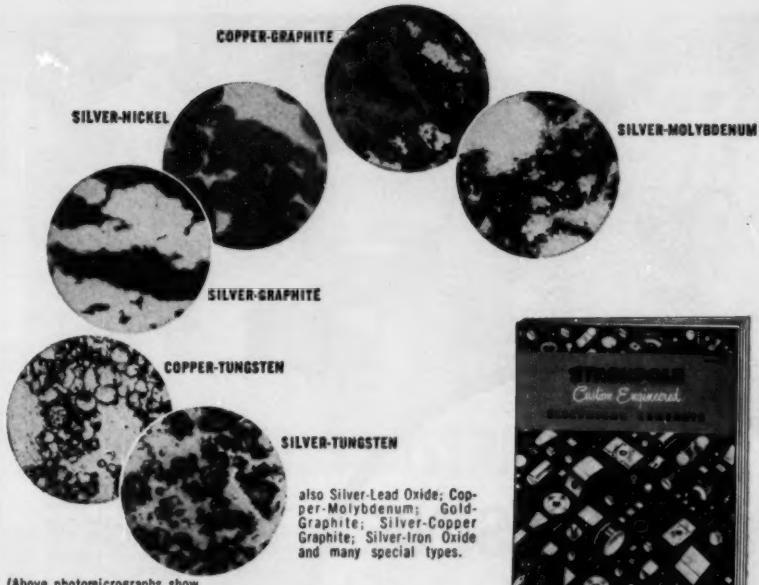
Apparatus is stable without floor attachments; low center of gravity permits free placement. Board, 40 x 60 in., is built for dimensional stability in any climate. Designed especially for use with Isis drafting machine (shown), table also accepts other machines. Isis Inc., Box 1062, York, Pa.

Circle 707 on Page 19

Miniature Torque Pickup

can be used with
belt or gear drive

Model MTE miniature torque pickup has torque readings from stall to 20,000 rpm. Five models are available in full-scale capacities of 50 to 1000 oz-in. at 0.25 per cent accuracy. Models can be used with belt or gear drive. Brush holder and lifter is a single assembly that can be changed by removing two screws. Brush holders are interchangeable and a spare can be in-



(Above photomicrographs show typical contact cross sections at magnifications of from 100 to 500 times.)

also Silver-Lead Oxide; Copper-Molybdenum; Gold-Graphite; Silver-Copper Graphite; Silver-Iron Oxide and many special types.

here's helpful selection and use data on
**THE CREAM OF OVER
1500 CONTACT GRADES**

Just off press, this 36-page Stackpole Catalog 13-A is a practical guide to composition contact grades, possibilities, properties, uses, shapes, sizes . . . even contact attachment methods.

By molding contacts from two or more metal or carbon-graphite powders, Stackpole Custom Engineering obtains a maximum of the advantages of each material and minimizes its disadvantages. The result is a greater overall efficiency than is generally possible with a single solid metal or alloy. Many of the most desirable contact metals cannot, of course, be alloyed satisfactorily but they can be made from powders in almost any desired proportion.

Composition contact engineering under exclusive Stackpole processes is characterized by its extreme flexibility in obtaining exact needed properties. This is best evidenced by the fact that over 1500 different grades representing different metallurgical mixtures have been produced for specific applications.

In various instances, their advantages permitted increased equipment ratings. In others, they paved the way to smaller, less costly equipment. Often, they simply combined long, trouble free operation with maximum economy.

This Booklet by no means attempts to present composition contacts as a universal answer to all problems. However, for design and production engineers who appreciate the basic logic behind them and who recognize that conventional contact types often leave something to be desired, it will provide a wealth of helpful information and guidance.

A copy may be obtained on letterhead request (ask for Catalog 13-A) to: STACKPOLE CARBON COMPANY, St. Marys, Pennsylvania.

STACKPOLE
CUSTOM ENGINEERED **CONTACTS**



Also: BRUSHES for all rotating electrical equipment; GRAPHITE CHEMICAL ANODES BEARINGS • SEAL & CLUTCH RINGS • VOLTAGE REGULATOR DISCS • FRICTION SEGMENTS CERAMIC MAGNETS . . . and many other carbon, graphite and metal powder products.



6-hp WISCONSINS are as rugged as their 30-hp big brother!



Rugged dependability runs in the Wisconsin Engine family. That's why a 6-hp "baby" ACN is just as durable on grueling jobs as the 30-hp VH4D. This fact—demonstrated by the high-speed tampers shown — also helps you separate heavy-duty engines — *Wisconsins* — from bargain types.

Wisconsins vary in size and weight, but not in quality or stamina. All have thrust-absorbing tapered roller main bearings, forged-steel crankshafts, and stall-preventing high torque. And all are precision-built to minimize wear and care.

The VH4D brings out the benefits of air cooling. It is smaller and much lighter than a water-cooled equal, thus making the equipment it powers lighter and more maneuverable. Air cooling also slashes servicing and upkeep. And Stellite exhaust valves and seats plus rotators extend valve life up to 500%!

Protect your equipment — power it with heavy-duty air-cooled Wisconsin Engines, 3 to 56 hp. We'll tailor the engine for you to cut your assembling time and costs. Send for Engine Bulletin S-249. Write to Dept. O-11.

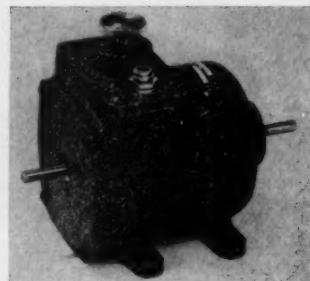


WISCONSIN MOTOR CORPORATION

MILWAUKEE 46, WISCONSIN

World's Largest Builders of Heavy-Duty Air-Cooled Engines

G-308



stalled in less than five minutes. Applications include testing and design of small motors, gyros, servo motors, synchros, and actuators. Lebow Associates Inc., 14857 W. Eleven Mile Rd., Oak Park 37, Mich.

Circle 708 on Page 19

Drafting Film

is blue-colored

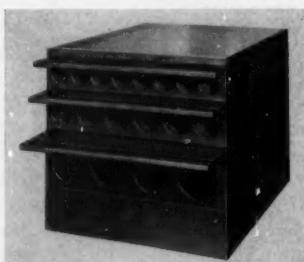
Mylar-polyester-base blue drafting film, Stascale, eliminates the need for use of special pencils—any ordinary graphite pencil from H to 5H can be used. Drafting surface also takes regular india ink. Film lies flat on the board. It erases easily without leaving ghosts, resists tearing, cracking, and abrasion. It will not chip, crack, peel, or wrinkle, and re-inks without feathering. B. K. Elliott Co., 536 Penn Ave., Pittsburgh, Pa.

Circle 709 on Page 19

Modular File

for all types of
rolled material

Moducor file system for rolled tracings, prints, and other rolled materials consists of four, six, and eight-tube modules in 4, 2 5/8, and 17/8-in. diam tubes. All modules are 18 3/4 in. wide to permit stacking for varying storage and activity requirements. Individual tubes are



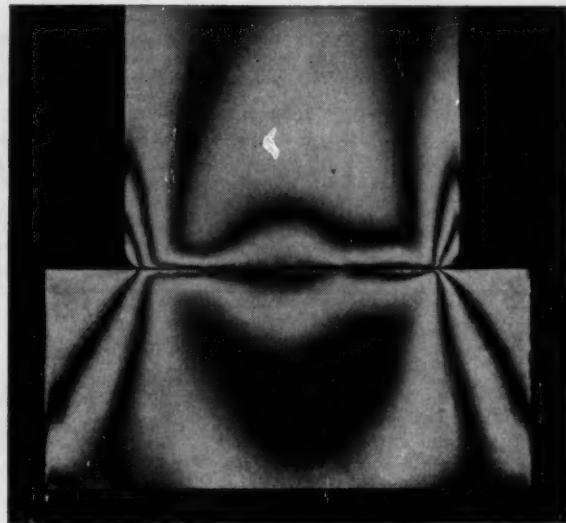
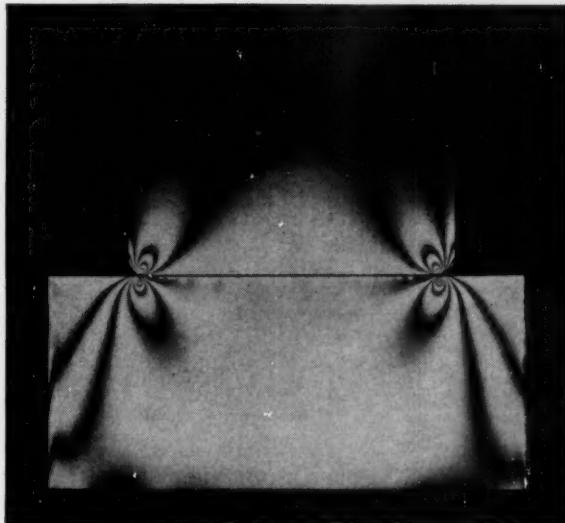
BEARING

BRIEFINGS



One in a series of technical reports by Bower

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION



These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the

roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher

speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Have a Pumping Problem that
requires

CUSTOM DESIGN?



Custom designed Viking
submersible type pumping
unit of solid stainless steel

Solve It With VIKING ROTARY PUMPS

Designing pumps to solve particular problems, and reduce costs at the same time, is a specialized Viking service. The custom unit shown above is an example. The situation called for a vertical, submersible pumping unit to handle a highly corrosive liquid. The completed result is all stainless steel below the plate at far right, including tank cover plate, base, structural supports, shafting, pedestal bearings, piping, coupling, fitting and Viking heavy-duty pump. The unit delivers 55 G.P.M. of a 5000 S.S.U. corrosive liquid under 90 P.S.I. pressure.

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See the Viking Pump exhibit at the Design Engineering Show, Booth #1231, Cobo Hall, Detroit, May 20-25



Circle 397 on Page 19

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BEVEL GEARS

Designers can now re-consider the use of bevel gears—due to the latest Gleason coniflex system of bevel gear proportions which we employ—to minimize gear mounting problems and for less trouble after assembly. Costs are less by this method, better finishes and smoother gear operations are a result, and because bevel gears are so efficient, they can now be used more extensively than ever before.

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Send blue prints or specs for prompt estimates to the specialists in the Fine Pitch Field.



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Circle 398 on Page 19

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paper laminate, foil wrapped with steel ends for maximum strength. They are moisture, dust, and smoke-resistant. Tubes are anchored mechanically in a metal frame to prevent accidental tube removal while permitting easy insertion of a new tube without tools, paste, or glue. Hinged door is held in open or closed position by spring tension without latches or catches. All modules are reversible so that doors may swing up or down. Lengths vary from 24 to 60 in. in 6-in. increments. Module heights vary according to tube diameter. Hamilton Mfg. Co., Dept. 385, Two Rivers, Wis.

Circle 710 on Page 19

Power Supply

has output of
0.5 w per cu in.



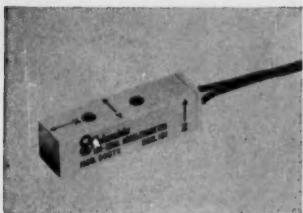
All-solid-state power supply combines a switching preregulator with a series regulator. High efficiency (80 per cent) of the unit provides output of 0.5 w per cu in. Unit has continuously variable current limiting from 0.1 to 3.1 amp, output of 0.40 v dc at 0.3 amp, and input is 105-125 v, 60-400 cps. Size of unit is 4-11/16 x 6-3/4 x 7-1/2 in., and weight is 14 lb. Valor Instruments Inc., 13214 Crenshaw Blvd., Gardena, Calif.

Circle 711 on Page 19

Triaxial Accelerometer

for shock and
vibration testing

Model 606-TX accelerometer is an ultraminiature sensing device for use in shock and vibration testing of printed-circuit boards, electron tubes, sheet-metal structures, internal bores, and other similar applications where mass loading is prohibitive or space requirements are



limited. Unit has a sensitivity of 2 mv per g along the x, y, and z axes and a flat frequency response from 0.5 cps to 8 kc within ± 5 per cent. Resonant frequency is 50 kc. Maximum acceleration is 1000 g and amplitude linearity is ± 2 per cent. Temperature range is -65 to $+350$ F for standard units. Stainless-steel case measures 0.4 x 0.4 x 1.5 in., and weight of unit is 8 grams. Columbia Research Laboratories, MacDade Blvd. & Bullens Lane, Woodlyn, Pa.

Circle 712 on Page 19

Drawing-Board Cover

has high "recovery" power

Markings left by compass points or sharp-edged instruments disappear quickly from new resilient vinyl-plastic Borco drawing-board cover. Both green and ivory surfaces are equally usable, and both have non-glare finish to reduce eye-strain. Surface is easily attached by the use of two-sided adhesive tape. It can be washed with fine-grained scouring powder to maintain bright, clean look. Unitech Corp., 50 Colfax Ave., Clifton, N. J.

Circle 713 on Page 19

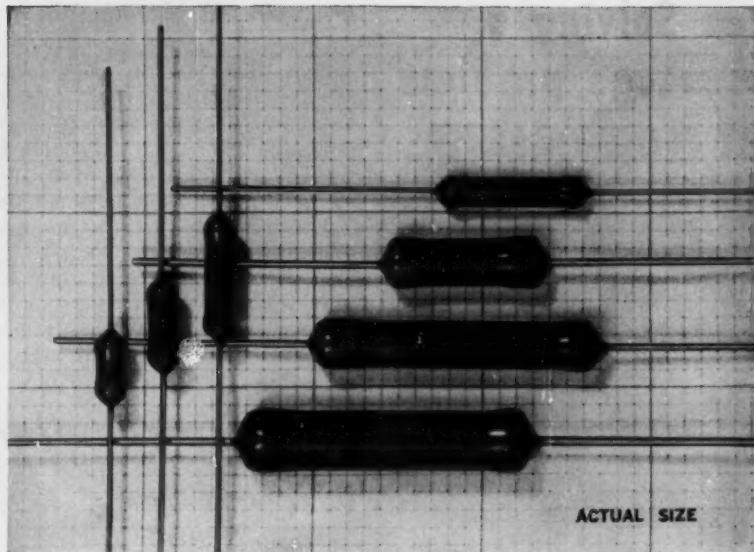
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April 13, 1961



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Rating (in watts)	Type	SIZES AND RATINGS		Length*	Diam.
		Min.	Max.		
2	2X	0.1	5,000	3/8	3/8
3	3X	0.1	10,000	1/2	3/8
4	4X	0.1	15,000	1 1/16	3/8
5	5XM	0.1	20,000	1 3/16	3/8
7	7X	0.1	25,000	1	3/8
10	10XM	0.1	50,000	1 3/4	3/8
12.5	12.5X	0.1	75,000	1 3/4	3/8

*Less leads.

Get complete details in Supplement C to Catalog 15. Write for your copy and a list of stocking distributors today. Ward Leonard Electric Co., 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)



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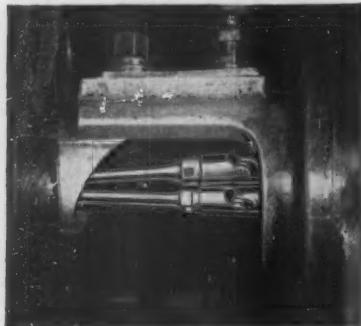
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Circle 399 on Page 19

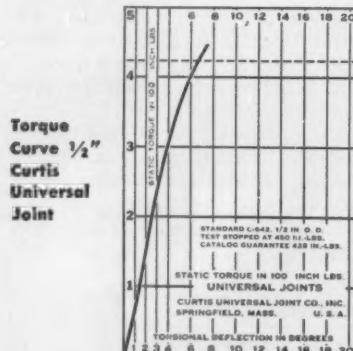
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Circle 405 on Page 19

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Circle 714 on Page 19

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occupies less than
2 1/2 sq ft of floor space

Penguin/5 environmental chamber has 0.5 cu ft capacity, occupies less than 2 1/2 sq ft of floor space, and is caster-mounted for ease of portability. Standard low-temperature



range is -10 to -65 F; unit is available with a high range to +500 F. Cincinnati Sub Zero Products, 3932 Reading Rd., Cincinnati 29, Ohio.

Circle 715 on Page 19

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are transparent

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Circle 716 on Page 19

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AND TECHNIQUES

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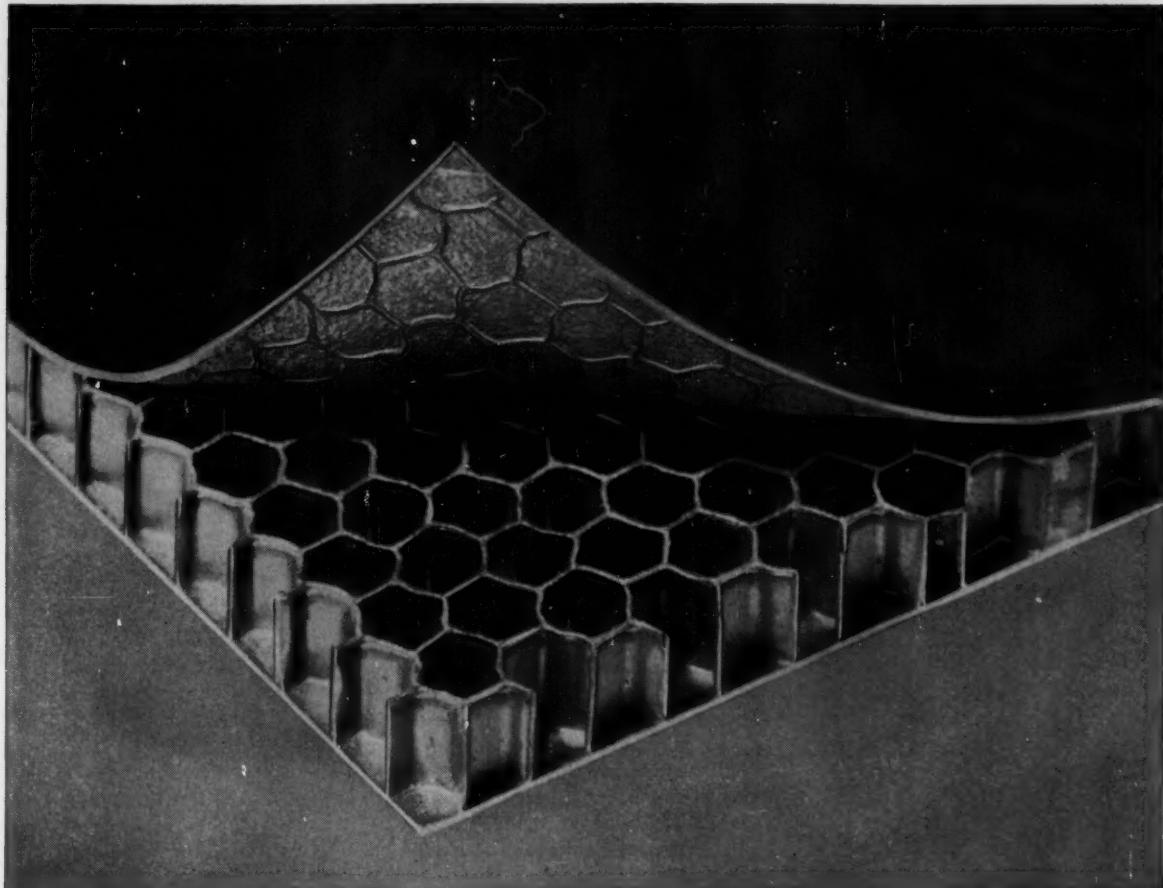
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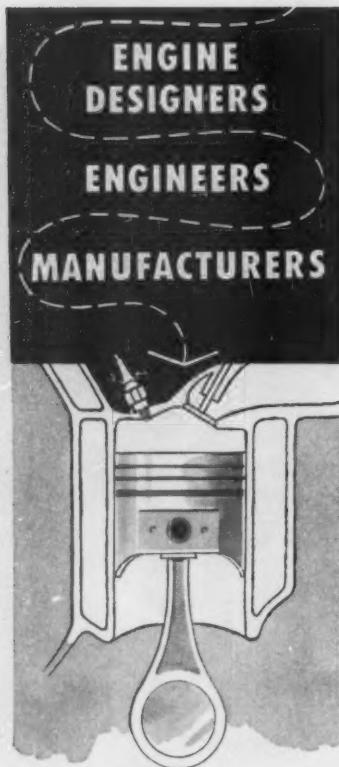
resulted in a brazing powder for honeycomb applications which has exceptionally low erosion characteristics and offers top strength even up to 1800° F.! It also provides superior "filleting" characteristics for better stress distribution in brazed joints.

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THE ENGINEER'S

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Recent Books

Centrifugal Pumps: Selection, Operation, and Maintenance. By Igor Karassik and Roy Carter; 496 pages, 7 1/4 by 10 1/4 in., clothbound; published by F. W. Dodge Corp., 119 West 40th St., New York 18, N. Y.; available from MACHINE DESIGN, \$15.75 per copy postpaid.

All types of centrifugal pumps are analyzed and illustrated. Pumps for many areas of industrial and utility service—including vertical, self-priming, and regenerative pumps—are discussed and specified.

Theory is only introduced where it is essential to understanding of specific problems in planning, selecting, operating, and maintaining systems. All parts of the pump unit are discussed and shown in detail—casings, impellers, shafts, stuffing boxes, seals, bearings, controls, couplings, supports, and balancing devices.

The Dynamical Theory of Sound. By Horace Lamb; 307 pages, 5 1/2 by 8 in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; \$1.50 per copy.

A comprehensive treatment of the dynamical aspects of sound theory is presented. Mathematics is used to a great extent in development of theory.

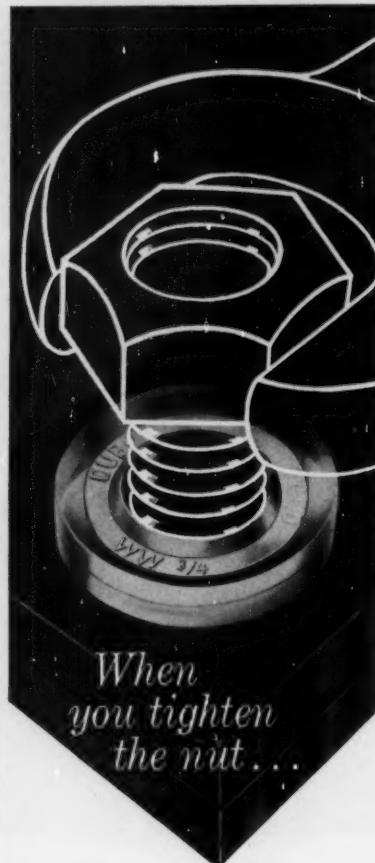
General topics include vibrations, strings, bars, membranes, sound waves, diffraction, resonance, harmonics, and physiological acoustics.

Modern Flight Dynamics. By W. Richard Kolk; 288 pages, 6 1/4 by 9 1/4 in., clothbound; published by Prentice-Hall Inc., Englewood Cliffs, N. J.; available from MACHINE DESIGN, \$10.00 per copy postpaid.

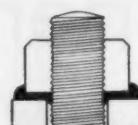
Analysis of flight-vehicle design is presented. This volume bridges the gap between airplanes and rockets with its particular emphasis on dynamic motion and stability of that motion.

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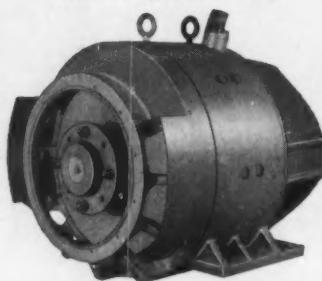
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grange's equation are treated first. Then, direction cosines and Eulerian angles are introduced. Finally, dynamics of flight vehicles are comprehensively analyzed.

Engineers and What They Do. By Harold Coy; 186 pages, 5 1/4 by 8 1/2 in., clothbound; published by Franklin Watts Inc., 575 Lexington Ave., New York 22, N. Y.; \$3.95 per copy.

This informative survey of the engineering profession points out the opportunities open to creative and imaginative individuals with engineering training. Information is especially helpful to those who might serve in an advisory capacity to determine qualifications for various engineering careers.

Optics and Optical Instruments. By B. K. Johnson; 224 pages, 5 1/2 by 8 in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; \$1.65 per copy.

Practical applications of optical principles are discussed. Sufficient theory is included so that experimental illustrations can be satisfactorily understood.

Topics include reflection and refraction, focal-length measurements, telescopes, microscopes, photographic lenses, optical-projection systems, and working and testing of optical glass.

Association Publications

Proceedings of the Eastern Joint Computer Conference. 342 pages, 8 1/2 by 11 in., paperbound; available from Institute of Radio Engineers Inc., 1 East 79th St., New York 21, N. Y.; \$3.00 per copy.

This volume contains 28 papers presented at the December, 1960, Eastern Joint Computer Conference in New York. Specific topics include data-processing techniques in design automation, high-speed data-transmission systems, high-speed printing and plotting, and use of a binary computer for data processing.

Symposium on Applied Radiation and Radioisotope Test Methods. 112 pages, 6 1/4 by 9 1/4 in., clothbound; published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; \$3.75 per copy.

This symposium presents the first concentrated efforts to develop pro-

posed ASTM methods of analysis and testing by utilizing radioisotopes as analytical tools. Topics include radioactive ring-wear testing in diesel locomotives, permeability tests for organic sheet materials, and radioisotope methods of testing uniformity of coated fabrics.

Technical Papers, Volume VII—Society of Plastics Engineers. 500 pages, 8½ by 11 in., paperbound; published by Society of Plastics Engineers Inc., 65 Prospect St., Stamford, Conn.; \$12.50 per copy.

This volume contains papers presented at the January, 1961, Technical Conference of Society of Plastics Engineers in Washington, D. C.

Specific topics of the 102 papers include strength of glassy polymers, states of polymers based on thermo-mechanical properties, hydraulic fluids, design for plastic finishing, properties of a new polyester film, adhesive bonding, and utilization of plastics in seal design for extreme environments.

Manufacturers' Publications

Feasibility Study of Large Diameter Anti-Friction Bearings for Radar Antenna Applications. By Howard W. Anderson, Halford L. Knotts, and John O. Predale, Kaydon Engineering Corp.; 227 pages, 8¾ by 11½ in., paperbound; published by Kaydon Engineering Corp., McCracken St., Muskegon, Mich.; \$25.00 per copy.

This research study provides a comprehensive reference for all types of large ball and roller bearings. Detailed discussions, formulas, and other specific data on the state of the art of large bearing design are presented.

Methods for obtaining bearings having maximum load-life capacity for support systems are analyzed. Theoretical investigations propose a new method of analysis to take into account the elasticity of bearings race rings and supporting structure when determining load and stress distribution within a bearing under thrust loading.

Westinghouse Lighting Handbook. 250 pages, 5½ by 7½ in., leatherette cover, ring binder; published by Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.; \$3.00 per copy.

This lighting-design manual contains information on characteristics



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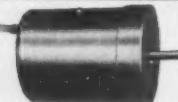
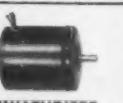
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Handbook of Noise Measurement. 132 pages, 7 by 10 in., paperbound; published by General Radio Co., West Concord, Mass.; \$1.00 per copy.

Noise and vibration measurement, sound-equipment requirements, procedures, and interpretation of results are covered. This fourth edition has been extensively revised to bring it up to date.

Such topics as the measurement of sound levels and sound-pressure levels, and application of sound-measurement systems are discussed. Also included are characteristics of noise control, typical noise sources, and speech interference.

Digest of Military Electronics. 210 pages, 6 1/4 by 9 1/4 in., clothbound; published by RCA Service Co., Government Services, Camden 8, N. J.; \$3.95 per copy.

This reference book presents and explains electronics terminology of modern military equipment and systems. Numerous unclassified military publications were used as reference sources for this compilation.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161076. Office of Scientific Research and Development Microfilm Index. 770 pages, 8 by 10 1/2 in., paperbound; \$5.00 per copy.

This index contains listings of declassified reports of the World War II Office of Scientific Research and Development. Reports themselves may be purchased only in microfilm or photocopy. Listed are titles of OSRD reports and necessary bibliographic information for ordering copies of the reports from Library of Congress.

Index is divided into 18 sections. Reports cover topics such as impact and explosion, guided missiles, transportation, optics and camouflage, and radar.

PB 151089. New Developments in the Welding of Metals. By P. J. Rieppel, Battelle Memorial Institute; 48 pages, 8 1/2 by 11 in., paperbound; \$1.25 per copy.

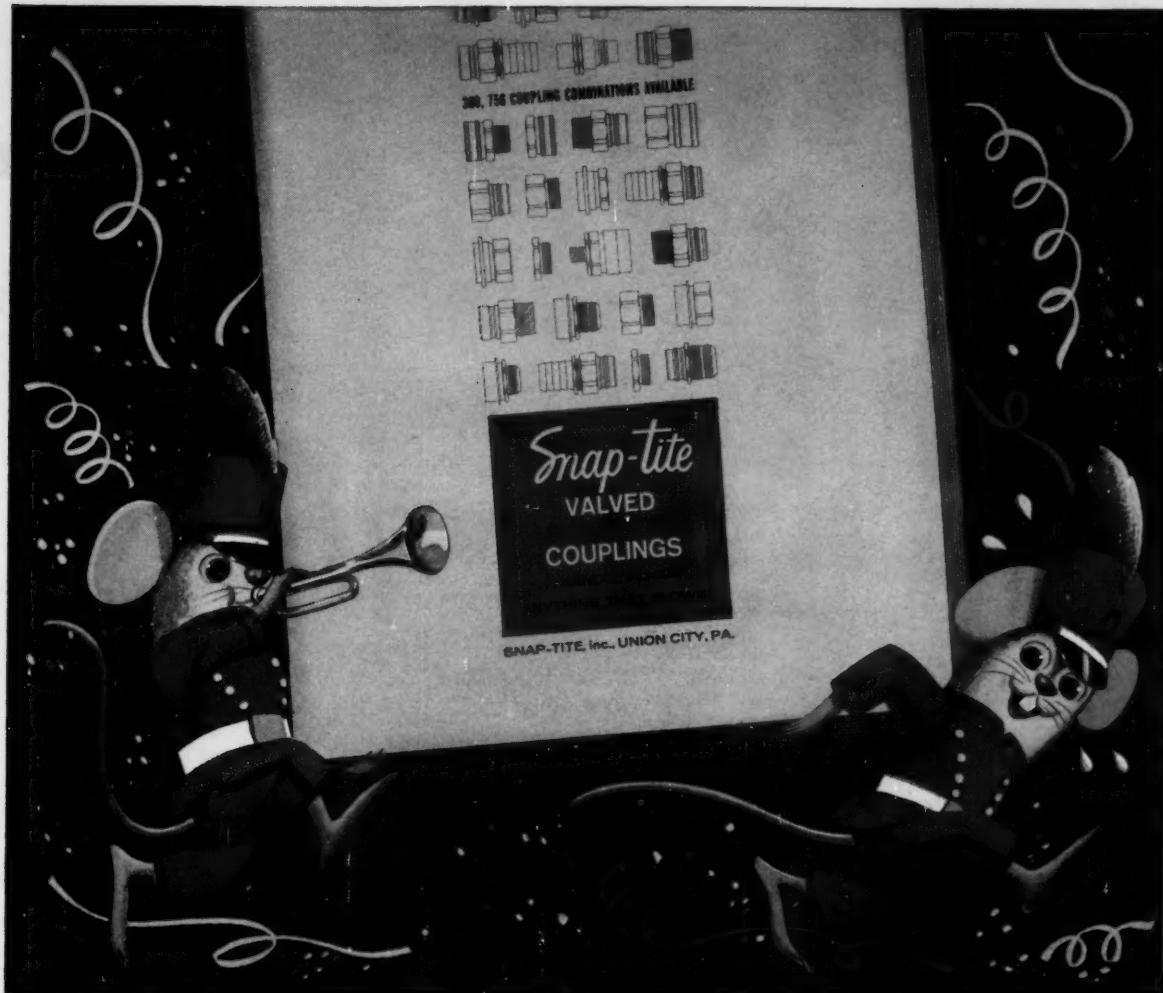
Applications and limitations of five welding processes are analyzed. Fusion welding, resistance welding, brazing, solid-state bonding, and cutting and coating (plasma jet) are studied.

PB 161027. Development of Printed Cables and Connectors. By Wilhelm Angeli; 23 pages, 8 by 10 1/2 in., paperbound, stapled; \$0.75 per copy.

Concept of utilizing flat conductors rather than round wires in electrical circuits is presented. Material selection, design data, and manufacturing possibilities are discussed.

PB 161888. Lubrication Behavior of Liquid Metals. By Patrick H. McDonald, North Carolina State College; 69 pages, 8 1/2 by 10 1/2 in., paperbound, stapled; \$2.00 per copy.

Hydrodynamic and boundary lubricating behavior of liquid metals was investigated. Reynolds equation of basic theory of hydrodynamic study was extended to a new state of development. Macroscopic theory of boundary lubrication was applied to a cylinder-flat combination, and the effect of contact stress on lubricating behavior was analyzed.



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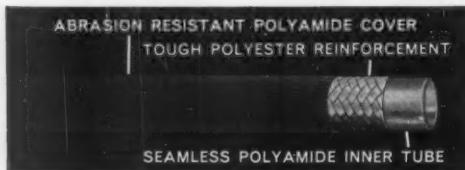
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more needs, cuts costs

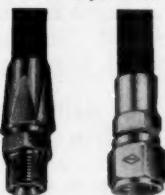
Hytron Hose, made with a seamless, extruded inner tube of special virgin polyamide, has a high-tensile-strength polyester braid reinforcement, plus extruded polyamide cover. Its strength compares with wire braid hose—its additional features open new design opportunities in hydraulic and pneumatic systems.

Compatibility—more uses

Hytron Hose is compatible with mineral or synthetic fluids having either water or phosphate ester base. Thus, you can use this one hose for more applications. Wherever you use S.A.E. 100R1 wire braid hose, Hytron should be considered.

Major advantages

- 7.2 times the flex life of wire braid hose.
- 2½ times more abrasion-resistance than rubber. High resistance to mildew, heat, sunlight, chemicals.
- Burst pressures from 9000 to 12,000 psi, depending on hose size and temperature. Temperature ranges from -40° to 250° F.
- Available in long lengths—up to 1000 ft. Sizes to ¾ in.
- 60% lighter weight than wire braid rubber hose.
- Low diametrical expansion.



Hytron Hose furnished as factory-made assemblies with permanently attached couplings, or with easy-to-install, re-usable couplings, in a wide range of sizes and styles.

HOSE

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April 13, 1961

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PUMP DESIGN TRENDS

ARTHUR A. NICHOLS

PUMP RELIABILITY GREATLY INCREASED BY NEW INTEGRAL DESIGN CONCEPT

- Building ultra-reliability into pumps by building the pumping elements themselves integrally into the casting or frame of the mechanism they serve is a recently developed concept now rapidly being adopted by designers.
- The development of three low cost elements ready to build into the housing of any mechanism requiring a pumping function eliminates the purchase of complete pumps.

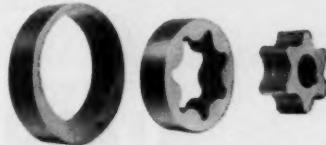


Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminating need for purchase and mounting of separate, complete pump.

- Mounting pads, couplings, connectors and accessory drives are done away with by this progress in design. Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply through-boring the casting or frame of the mechanism to accommodate the locator ring O.D. and to provide porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft.

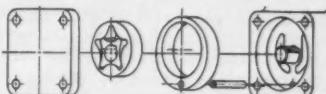


Fig. 2. Nichols Integral pump-package is easily installed integrally into most mechanisms.

- The matched elements are as easily built-in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi.

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Circle 415 on Page 19



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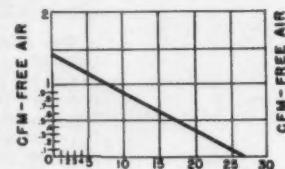
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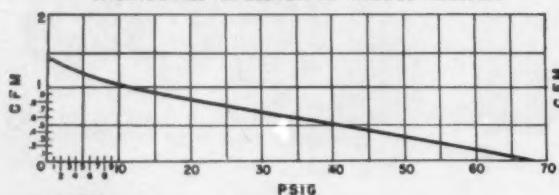
No chance of oil-spoiled work—not a drop of oil can be found in this compact, lightweight compressor. Motor and compressor are permanently grease-packed...carbon-graphite piston rings and skirts operate for years without injury to the cylinder walls. Since the cylinders are not oil-lubricated, air is always oil-free—no oil separator needed—no costly lubrication maintenance.

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are available in 58 models—
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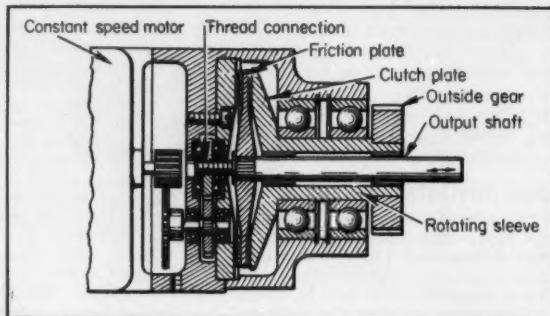
Circle 416 on Page 19

NOTEWORTHY

Patents

Variable-Power Constant-Speed Drive System

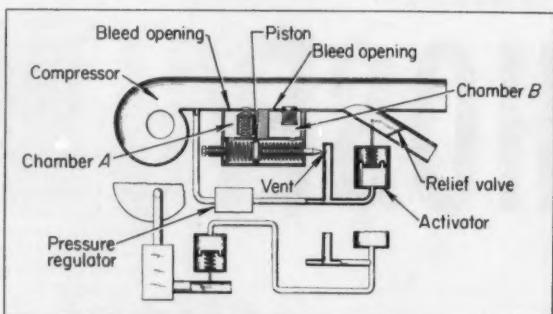
An outside power source is used to multiply the power output of a fractional-horsepower constant-speed drive system without affecting performance of timing or control operations. The additional power source is fed in by an outside gear through a rotating sleeve and clutch assembly. When the output shaft is moved axially (to the right), through a threaded connection,



a friction plate contacts the clutch plate to engage the shaft, which is normally driven by a constant-speed motor, with the outside power source. The power at the shaft may be multiplied by a factor of from 10 to 100 without loss of accuracy of timing or control functions. Patent 2,971,401 assigned to M. Ten Bosch Inc., Pleasantville, N. Y., by Maurits Ten Bosch and Paul Lang.

Surge-Pressure Relief System

A relief valve for a compressor system opens to relieve pressure surges but remains closed under gradual pressure variations. Normally, vented air prevents a build-up of pressure against the diaphragm of the relief valve activator. A sudden pressure increase, however,

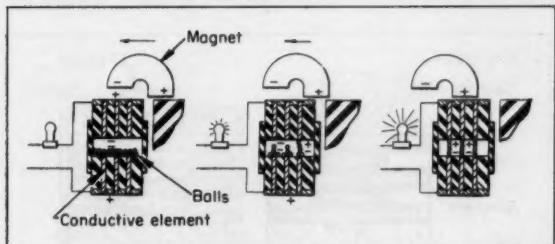


opens the check valve in Chamber A causing the piston to move to the right. This movement closes the vent opening so that the activator opens the relief valve by

an amount proportional to the discharge line pressure. For a sudden pressure decrease, the check valve in Chamber B opens to provide similar relief action. Bleed openings maintain equal pressures within the chambers for gradual pressure variations, so that air is constantly vented during normal operation. Patent 2,969,805 assigned to Fairchild Engine and Airplane Corp., Bay Shore, N. Y., by David U. Hunter.

Proximity Switch

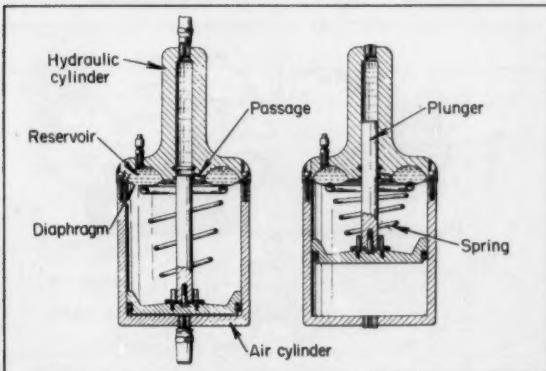
Magnetizable balls, housed within a cavity formed by a pair of grids, make or break the circuit in a proximity switch. Each grid is conductively joined at one end with the grid elements which are aligned to provide



focused flux paths. A permanent magnet controls the polarity and strength of these flux paths. As the magnet is moved across the grids the longer leg of the magnet produces a change in flux and a reversal of polarity in the ball cavity, creating a magnetic circuit. The balls are attracted to the focused flux paths and form conducting chains between the elements of the grid. Patent 2,972,029 assigned to Tann Corp., Detroit, Mich., by Stanford R. Oshinsky.

Leakage-Compensating Hydraulic Intensifier

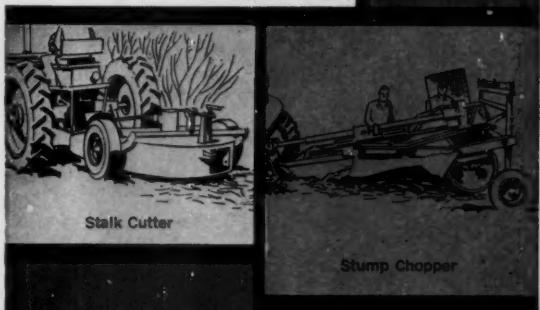
A built-in fluid reservoir in a "one-shot" type of air-operated hydraulic intensifier provides a constant supply of hydraulic fluid to replenish system losses caused by leaks. Mounted at the top of the low-pressure air cylinder, a diaphragm of synthetic rubber forms one



wall of a reservoir which is connected to the hydraulic cylinder bore by a passageway. When the passageway is uncovered by the hydraulic plunger, the pressure



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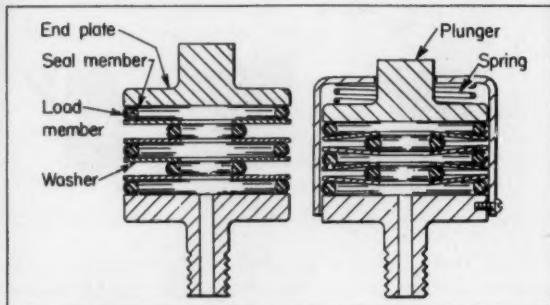
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NOTEWORTHY PATENTS

imposed on the diaphragm wall by a spring in the air cylinder forces fluid into the hydraulic cylinder. Thus, the fluid charge in the hydraulic system is maintained at all times. The passageway is covered by the initial movement of the hydraulic plunger so that the reservoir is not subjected to the high pressures produced. Patent 2,972,867 assigned to AMP Inc., Harrisburg, Pa., by Martin L. Klinger.

Built-Up Bellows

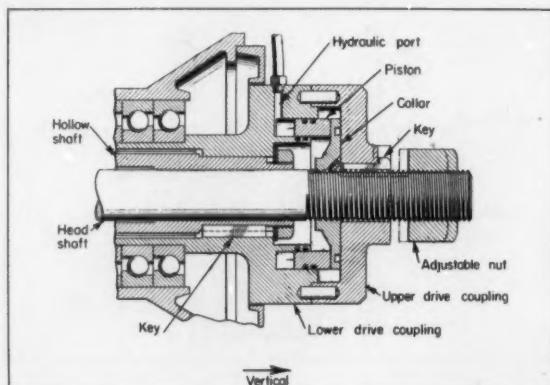
A bellows is built up to any desired dimension by stacking washers and load-seal rings. Rings are constructed in two parts: A load supporting member of relatively incompressible material, and a resilient sealing member. Load exerted on the plunger deflects the



washers against fluid pressure in the chamber, causing the resilient sealing members to move radially toward the load members. Mechanical loads are always in excess of the fluid loads to insure adequate sealing. Patent 2,973,015 assigned to Sabre Research Corp., Daytona Beach, Fla., by Tom H. Thompson.

Vertical-Shaft Adjusting Mechanism

A hydraulic lifting mechanism temporarily elevates the shaft of a vertically mounted pump so that axial position adjustments can be made with ease and without damage to component parts. A head shaft, which is driven by a powered hollow shaft through an upper

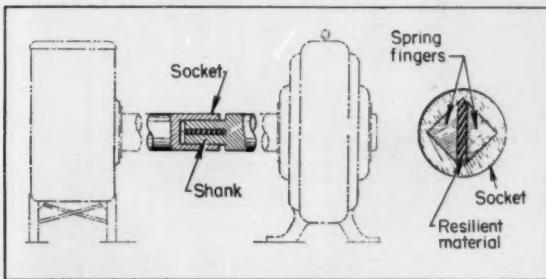


and lower drive coupling, has a threaded collar. A piston, under hydraulic pressure, engages the collar and

lifts the shaft to provide clearance between the adjusting nut and the upper drive coupling. In this position, the adjusting nut may be readily moved to alter the clearance. When hydraulic pressure is released, the shaft lowers to the new position determined by the adjusted position of the nut. Patent 2,964,015 assigned to U. S. Electrical Motors Inc., Los Angeles, Calif., by Albert Jack Garey.

Flexible Shaft Joint

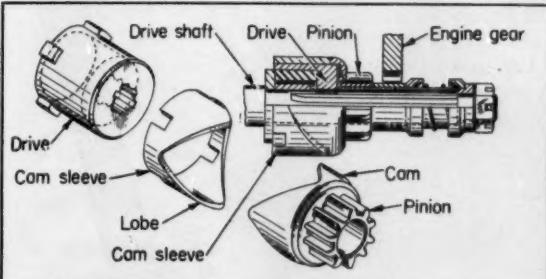
Spring fingers on one shaft slip into a mating socket on another shaft to provide a flexible joint which accommodates misalignment and cushions shock loads. The cross sectional area of the slit square shank on one shaft is slightly larger than the mating square



recess in the socket of the other shaft. Thus, the fingers of the shank, act as spring wedges. A compressible, resilient material fills the slit to exert outward pressure on the fingers and to cushion shock. Patent 2,973,214 assigned to the United States of America as represented by the Secretary of the Navy, by Richard L. Bates and Ralph G. Zagnailoff.

Reversible Engine Starter

A starter for small two-cycle engines cranks in either direction of rotation, eliminating the need for reverse gearing. Symmetrical axial cam lobes on a cam sleeve and a meshing pinion cam provide clockwise or counterclockwise engaging surfaces. Rotation of the drive shaft is transmitted through the drive member



to the cam sleeve. This sleeve, in turn, moves the pinion into mesh with the engine gear by the action of the cam lobes. The cranking torque may be limited by forming the cam lobes to slip past each other when

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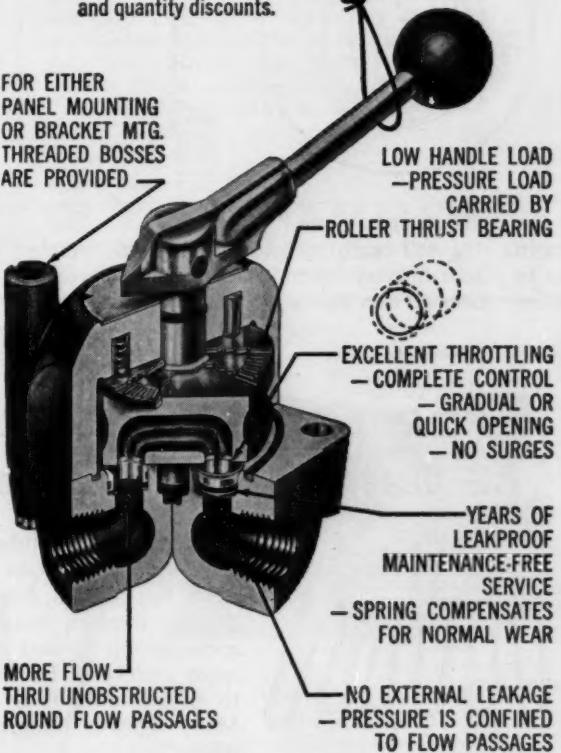
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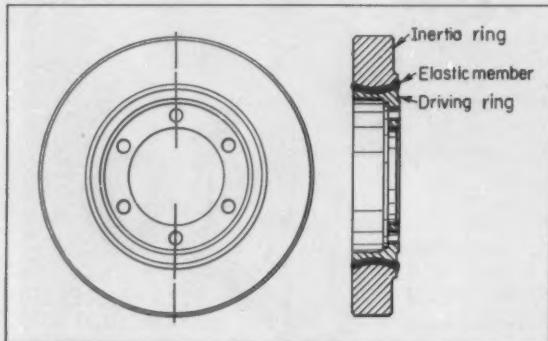
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NOTEWORTHY PATENTS

a predetermined maximum value is exceeded. Patent 2,972,275 assigned to The Bendix Corp., by Edwin Elliott Hood.

Torsional Vibration Damper

The elastic member in a shaft vibration damper has a curved cross section to prevent slippage between adjacent rings under axial load. An axial force on the inner driving ring and an equal opposite force on the outer

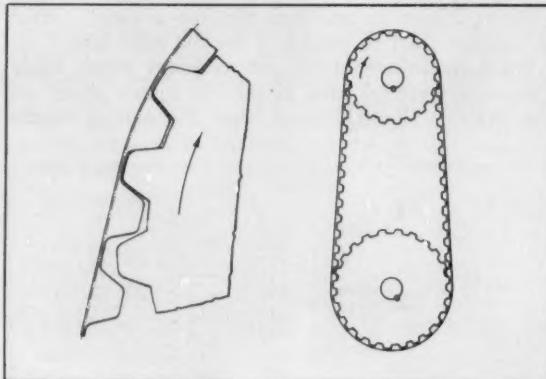


inertia ring will cause portions of the elastic member to be placed in compression. This compression of the elastic member develops a wedging action to main-

tain the relative positions of the members. Patent 2,972,904 assigned to Schwitzer Corp., Indianapolis, Ind., by William J. Troyer.

Toothed Metal Drive Belt

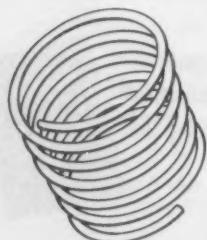
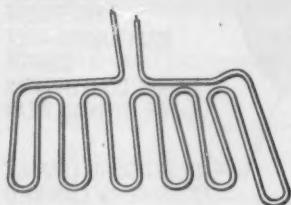
An endless toothed metal belt is formed in one piece. The belt is made from a forged ring, first by machining the gear teeth, and then by grinding the outside diameter to the required thickness to provide flexibility. The design offers high strength and quiet running characteristics, and is suited for use where high speeds or extreme temperature differentials are encountered. The



all-metal construction also resists the normally deteriorating effects of lubricating oil. Patent 2,971,392 as-

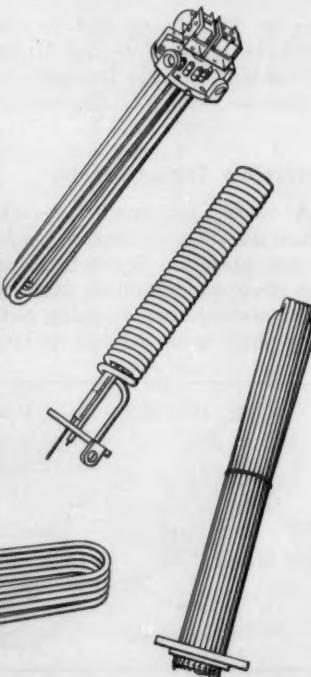
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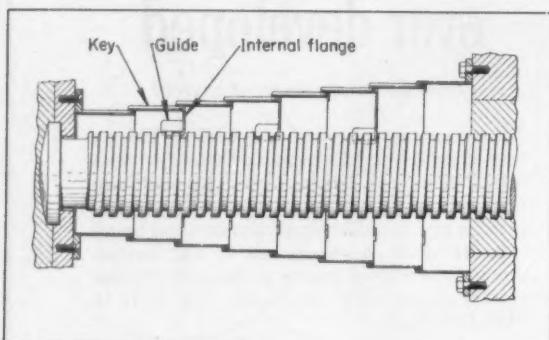
297

NOTEWORTHY PATENTS

signed to United States Rubber Co., New York, N. Y., by Richard Y. Case.

Telescoping Shaft Shield

A telescoping shield for traversing shafts or screws is held in alignment throughout its travel without auxiliary external supports. The shield assembly is rigidly connected at each end to the base members by bolts and screws. Each underlapping shield section

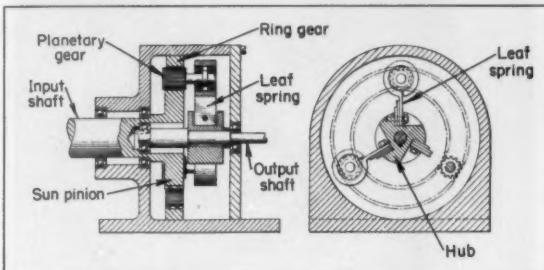


is fitted with an external longitudinal key. These keys ride within welded, internal rings on each section to prevent rotation. Alternately spaced internal flanges

are fitted with guides to provide internal support and to prevent the telescoping sections from cocking. Patent 2,971,399 assigned to McGraw-Edison Co., by Samuel S. Roberts.

Backlash-Compensating Planetary-Gears System

Planet gears in a precision train are mounted on leaf springs to minimize train error. The leaf springs are secured at their inner ends to a hub which is in turn



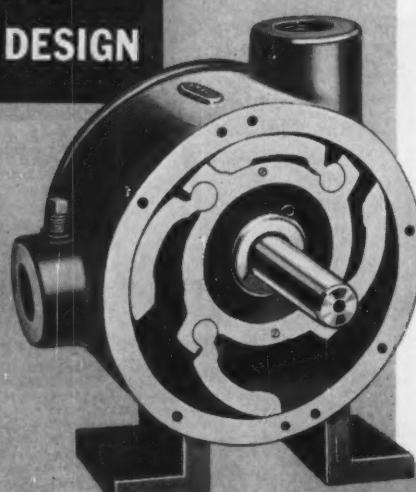
mounted to a signal-transmitting output shaft. The inherent stiffness of the relatively short, cantilever spring supports provides a backlash-compensating mounting that acts to average the positional errors in each gear mesh. The torsional stiffness of the springs may be augmented by stepped helper springs. Patent 2,971,407 assigned to General Motors Corp., Detroit, Mich., by Edwin F. Katz.

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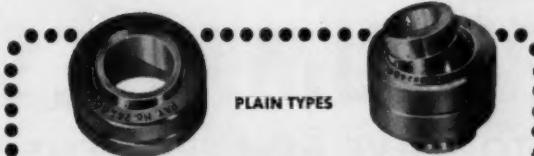
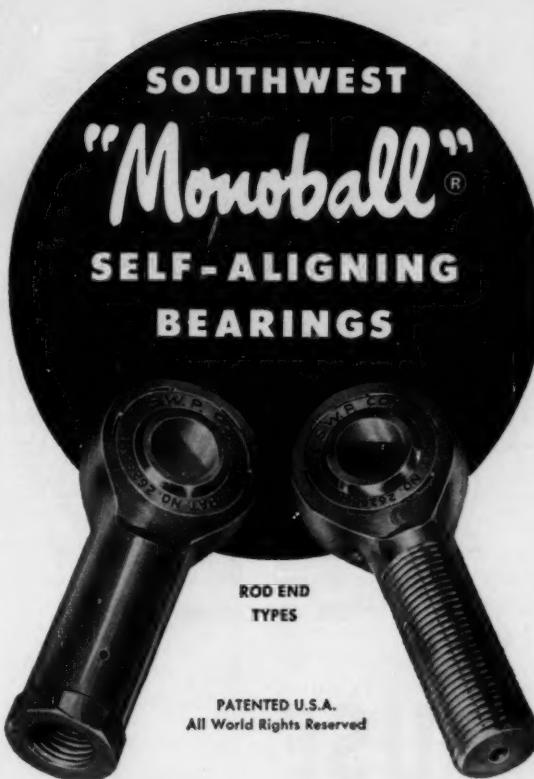
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For types operating under rotational, high radial loads and long cycle life where lubrication is impossible.



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ANALYSIS

1 Stainless Steel Ball and Race

2 Chrome Alloy Steel Ball and Race

3 Bronze Race and Chrome Steel Ball

4 "Dyflon"® Plastic Alloy Inserts, CRES Chrome Alloy Steels.

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For types operating under high radial ultimate loads (3000-893,000 lbs.).

For types operating under normal loads with minimum friction requirements.

For types operating under rotational, high radial loads and long cycle life where lubrication is impossible.

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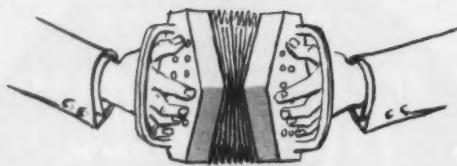
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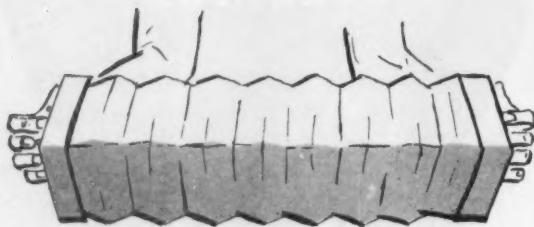
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Circle 427 on Page 19

299



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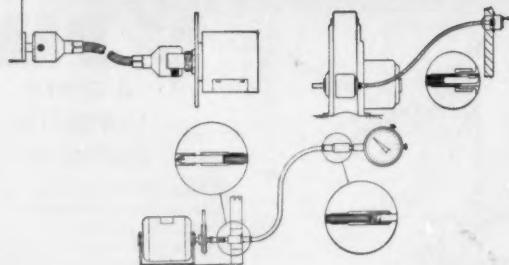
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Circle 429 on Page 19

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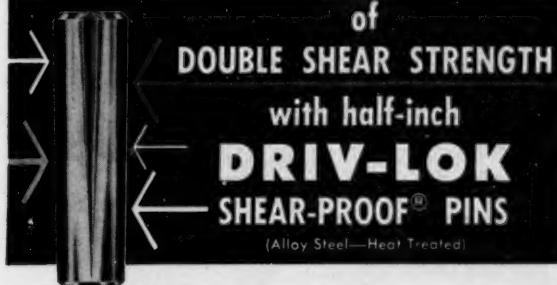
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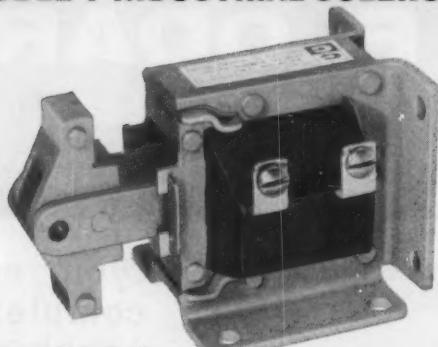
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Pioneers in the
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301

DOUBLE T INDUSTRIAL SOLENOID

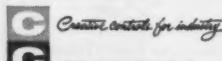


NEW compact design — greater pull-power... 20% faster cycling

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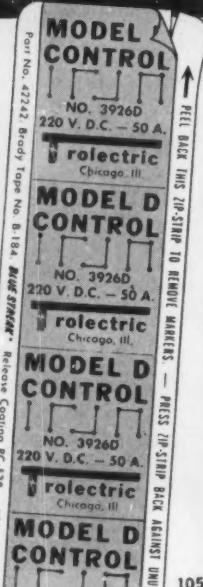
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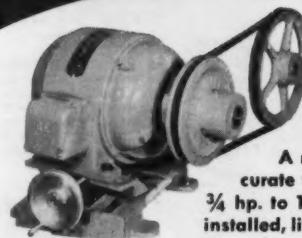
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105

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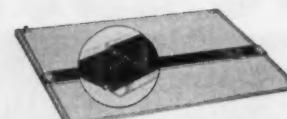
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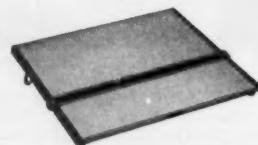
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Circle 438 on Page 19

Get Easier, More Accurate Cylinder Speed Control

Pneu-Trol® VALVES
IN AIR OR HYDRAULIC USE

2,000 (brass or aluminum) and 5,000 (steel) p.s.i.

Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle valve for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — $\frac{1}{8}$ " to $\frac{3}{4}$ ". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

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Inlet speed control for Double Acting Cylinder. Single Acting Cylinder Speed Control. Flow Control Valve. Check Valve. Needle Valve.

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Circle 439 on Page 19



IN YOUR NEXT PROJECT

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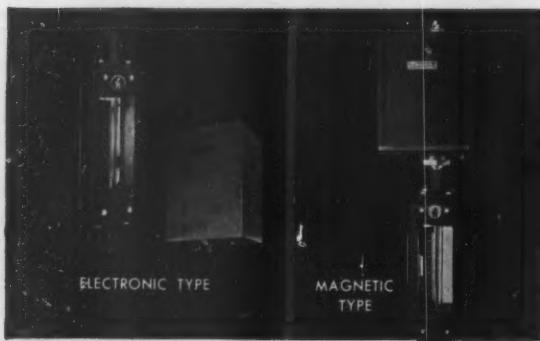
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303

ALARM ROTAMETERS

SIGNAL ABNORMAL FLOW RATES

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1/35 to 1/10 hp.

Then switch to Carter *Classic*

Interchangeable with competitive types. Exclusive performance features include longer brush life, instrument quality ball bearings in steel sleeved housings, highest quality die-cast construction.



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As your specialty motor source, there are no restrictions on modifications, no long delivery, no minimum orders . . . just friendly, personal attention to your requirements.

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Large Enough to Serve You, Small Enough to Want to

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Horizontal or vertical drives; inputs from either side; right, left, top or bottom outputs. A size and type for every application. Ratings from 1/20 to 400 h.p. Ratios up to 10,000 to 1.

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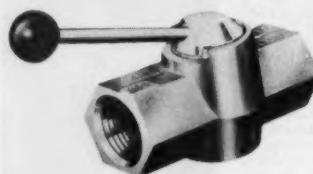
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SERVICE**



9200 SERIES

Positive sealing in high vacuums to 150 psi. Sizes 1/8", 1/4", 3/8", 1/2", 3/4". Available in brass or 303 stainless.



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puts a customer in clover

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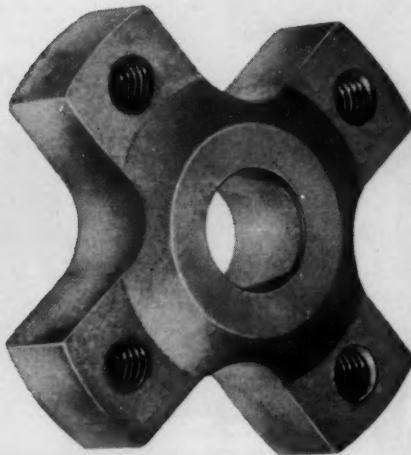
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powder metal parts, bearings, filters.

2 NEW BEARING STOCK LIST
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Circle 445 on Page 19

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Use Heat-Rem H-170
up to 1700°...18 colors

Are you working out a
problem with a surface
that's "too hot to paint"?
Heat-Rem H-170 may
be the answer.

Available in 18 high heat resisting shades,
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metal surfaces . . . forms a bright finish
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THE MANUAL



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NEW HAMPSHIRE BALL BEARINGS, INC.
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Circle 447 on Page 19

305

WITH  VERSA

UNLIMITED MANIFOLD MOUNTING OF VERSA SERIES "A" SOLENOID VALVES



Now... You can mount an unlimited number of Versa Series "A" Solenoid Valves as one integrated unit with these new Versa Co-Ordinate Assemblies. These assemblies make possible simplicity of design in both Hydraulic and Pneumatic operation, because only one inlet is required to feed the entire line of valves. Additional blocks can be added at any time and blocks with and without adjustable built-in bleed controls can be used together in one unit. Combined with Versa Series "A" Valves, these Co-Ordinates provide the most flexible and reliable Multiple Solenoid Valve Assemblies in the Control Valve field. Write for Bulletin # 960.

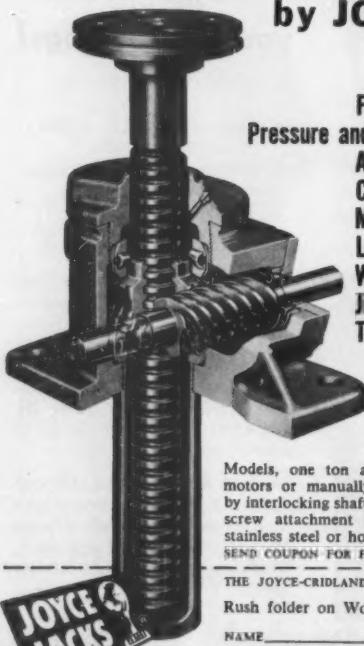


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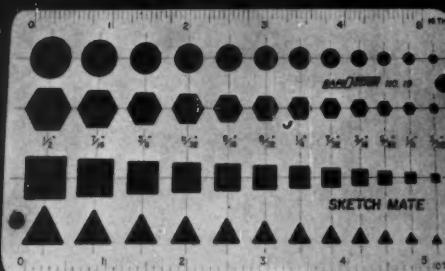
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RAPIDESIGN INC.

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Circle 451 on Page 19

TRANSMISSIONS featuring Electro-Magnetic Control



9000-B (1-10 H. P.)

TOQUE RATING:
1400 pound inches
output
350 pound inches input

HOSEPOWER RATING:

5 H.P., 900 r.p.m.
input

10 H.P., 1800 r.p.m.
input

GEAR RATIOS:

1:1-2:1-3:1-4:1

Special ratios at extra cost

Maximum Reduction 5.07:1

8100-B (10-20 H. P.)

TOQUE RATING:
700 pound inches input
2800 pound inches output

HOSEPOWER RATING:

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input

20 H.P., 1800 r.p.m.
input

GEAR RATIOS:

1:1-2:1-3:1-4:1

Special ratios at extra cost

Maximum Reduction 6.00:1

14800 (left)—Four special speed changes up to limit of case 10:1

14800 (right)—Four speed changes in geometric progression at 1.71 (total reduction of 5.03)

TOQUE RATING:

1400 pound inches input
7500 pound inches output

HOSEPOWER RATING:

20 H.P., 900 r.p.m.
input

40 H.P., 1800 r.p.m.
input

Transmissions with Electro-Magnetic Clutches provide speed changes and reversing under power, without interrupting power source . . . so equipped are available with two to eight speeds, capacities from 52 to 750 foot pounds and a wide ratio selection (up to 10:1). Manual or automatic controlling of speed changes accomplished with electric switches, tape, cam or other remote control means available. Especially adaptable to automatic machinery where transmission is not accessible to the operator.

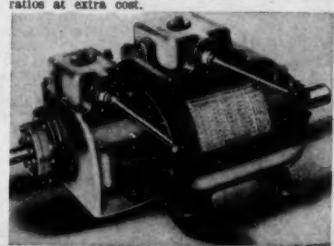
9300 (30-60 H. P.) left

TOQUE RATING: 2100 lb. in. input: 12,000 lb.

17 output

H.P. RATING: 30 H.P. at 900 R.P.M. 60 H.P.

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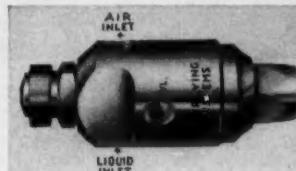
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complete information**

WESTERN TRANSMISSIONS

WESTERN MANUFACTURING CO. — 3400 SCOTTEN AVE. — DETROIT 10, MICHIGAN

Circle 452 on Page 19

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NOZZLES**



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Precision built for exact control of spray type and volume. Compact and easily installed. Write for Catalog 24.

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system . . . see Catalog 24 for
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NEW HAMPSHIRE  **BALL BEARINGS, INC.**
PETERBOROUGH, N. H.

Circle 453 on Page 19

Circle 454 on Page 19

307

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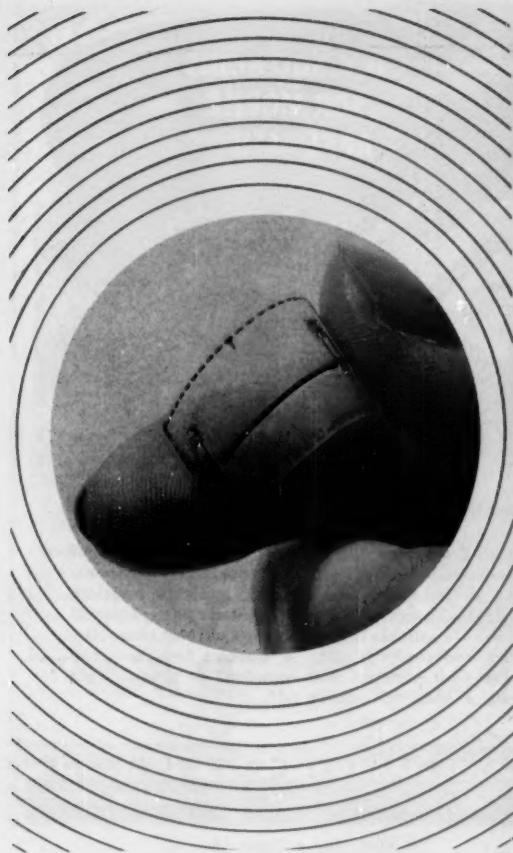
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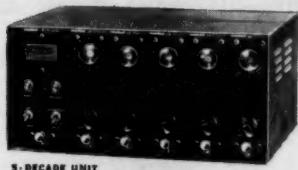


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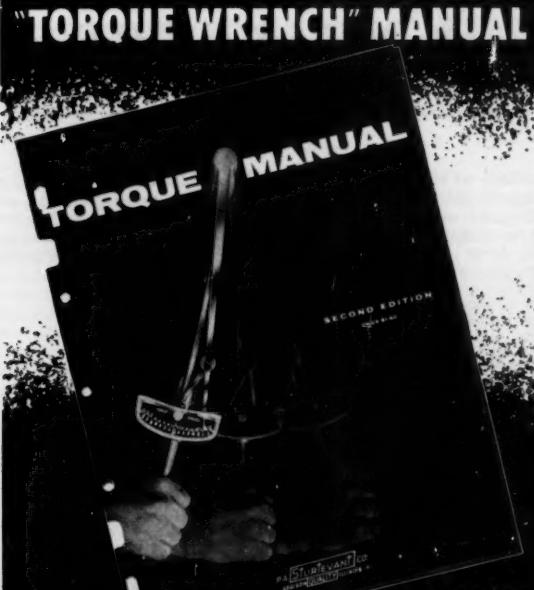
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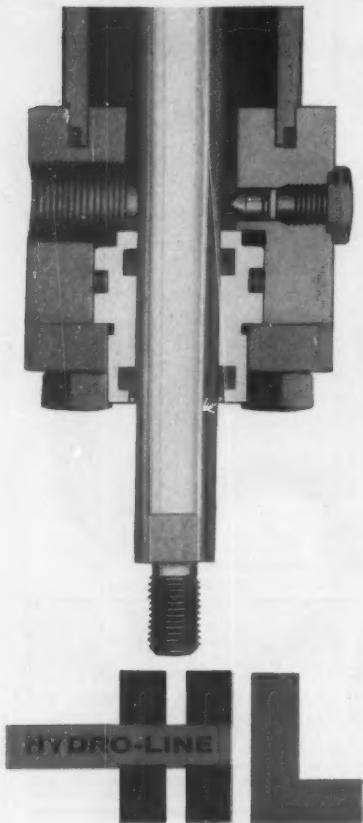
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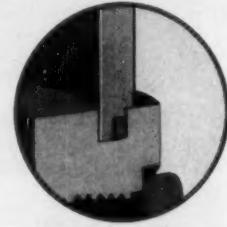
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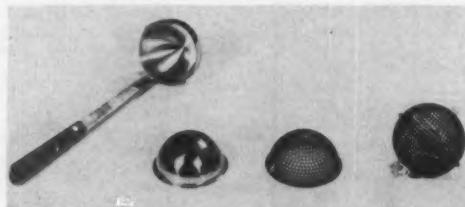
Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, \$10. Single copies \$1.00. Other countries: One year, \$25. Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



backtalk—

— From Soup to Space

A perforated stainless-steel sphere was to be custom-made for use in an Air Force rocket—until a thinking rocket-maker spied the soup ladle pictured below. Alfred R. Cate, an employee of the Engineering Requirements Branch



of the Geophysics Research Directorate at Hanscom Field, Bedford, Mass., came upon the ladle in a hardware store, then checked its measurements against specifications of the sphere. They were just right, so two tools, originally destined for the most mundane of kitchen chores, were adapted for a glamorous assignment in a space-probe payload.

— Progress in Pains

The crank-start automobile, which some of us will admit that we remember, was a pain in the neck—and could be a pain in the arm. If you went about your cranking with an excess of energy and a minimum of technique, you could even manage to break the arm.

Although the electric starter has eliminated this particular hazard to driving, another modern convenience threatens the well-being of motorists. The "garage-door syndrome," diagnosed by an Atlanta physician, is a severe pain that suggests a heart malfunction; actual cause is strain from opening an overhead garage door too vigorously.

— Space-Age K-9

A story about a dog and a rocket is not unique, but when the dog is part of the ground crew instead of the payload—that's news.

At Vandenberg AFB, a small, mixed-breed dog named Kim simplified the stringing of cables from blockhouse to launching pads, through covered trenches. Before Kim went to work, the job required cranes to remove some of the heavy trench covers, which then had

to be resealed after replacement. Kim was trained to travel the length of the trench, trailing a nylon cord. When he arrived at the far end of the tunnel, the cord—tied to the cable—was pulled through. This method cut the job from 32 to 4 manhours—and a fraction of a doghour, for which Kim charged only a stick of spearmint gum.

Kim's biographers in *Douglas Aircraft Airview News* regretfully report that the little dog died recently after being hit by a car. However, he left his mother and brother, either of whom may be Vandenberg's next "missile mutt."

— Custom Coolers

"Tis spring, and the picnic season is only a thaw away. A reminder of this fact came the other day in the form of news of a do-it-yourself, insulated food-container kit. The ingredients of the kit produce about a cubic foot of foam, which can be molded—in two nested boxes, or around a container—to the shapes and sizes desired. The white material can be colored or painted, and it can be tooled with a knife. Food will stay cold or warm from 12 to 24 hours in a Plasti-Foam-insulated container, according to the developer, Polystructures Inc., Stoneham, Mass.

— Hot Tip on Hot Dip?

Ideas on new applications and markets for hot-dip galvanizing may be worth \$1000, a medal, and a certificate of achievement. An award program that is "not a contest, but a search for ideas" has been established by the American Hot Dip Galvanizers Association, with the co-operation of the American Zinc Institute. Ten awards are offered, but more will be given if enough entries warrant them. Ideas must pertain to application of hot-dip galvanizing to a new or unusual field, an improvement in application where the process is now being used, or new methods of after-treatment of products.

Entries will be accepted until May 1, 1962. Complete information is available from American Hot Dip Galvanizers Association, 5225 Manning Place N.W., Washington 16, D. C.

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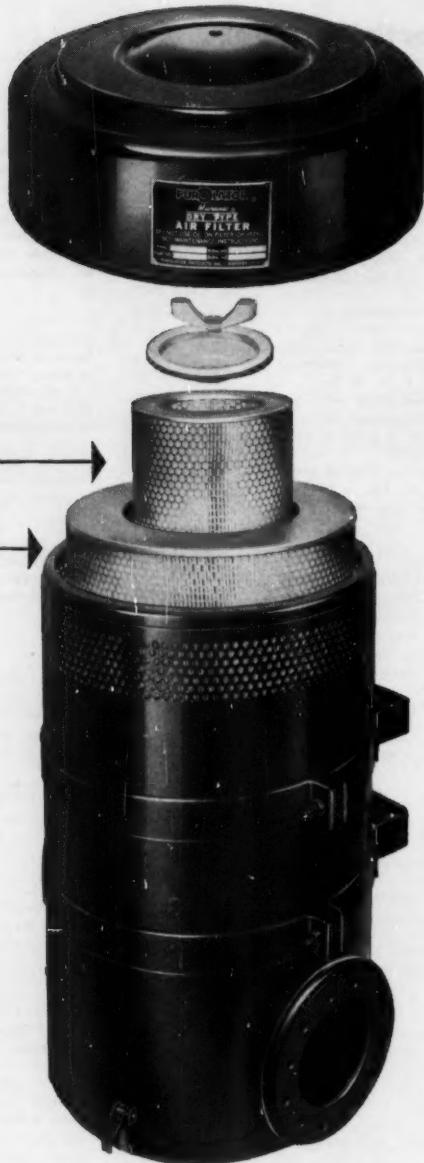
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